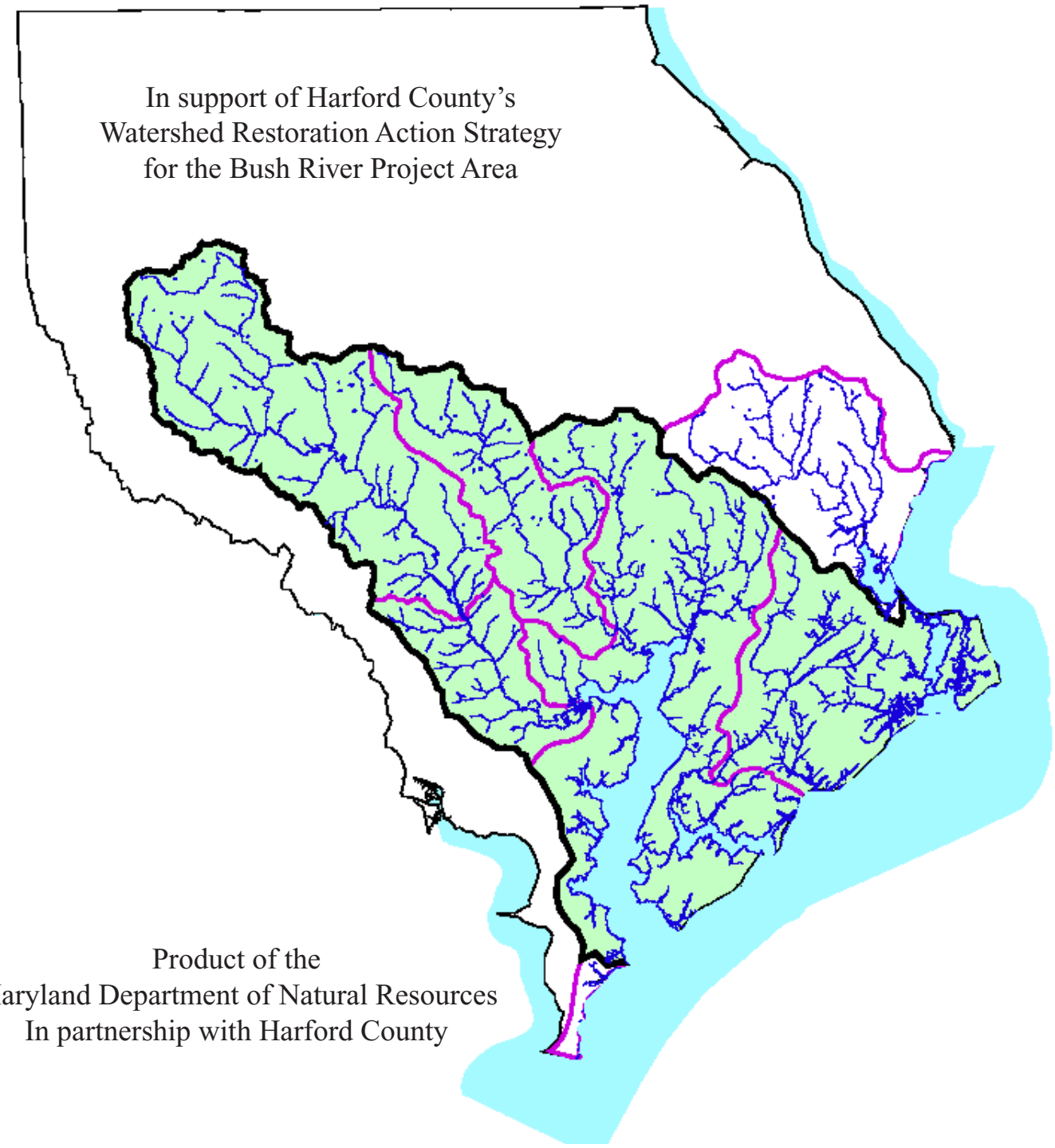
Bush River
Watershed Characterization

September 2002

In support of Harford County's
Watershed Restoration Action Strategy
for the Bush River Project Area



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The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

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Bush River Basin Characterization
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For the Bush River Basin Characterization

Harford County, Maryland is receiving Federal grant funding to prepare a Watershed Restoration Action Strategy (WRAS) for a project area in the Bush River Basin (Maryland 6-digit watershed). Two Maryland 8-digit watersheds in the WRAS project area are State-identified priorities for restoration: Bush River and Bynum Run. The WRAS project area encompasses nearly 119,600 acres including about 10,845 acres of open water.

As part of WRAS project, the Maryland Dept. of Natural Resources (DNR) is providing technical assistance. For example, DNR is working with the County to prepare a Watershed Characterization which is a collection of available water quality related information and identification of issues that may be used as the County generates its Watershed Restoration Action Strategy.

Water Quality

Five of the six Maryland 8-digit watersheds in the Bush River Basin are identified in the State's 303(d) list for not supporting their designated use. The causes appear to be related to four general categories of water quality problems: 1) nutrients in tidal waters and lakes, 2) suspended sediment in both tidal and nontidal waters, 3) toxics substances found near Aberdeen Proving Ground, and; 4) biological limitations identified in specific nontidal stream segments. As one step toward remedying these problems, Total Maximum Daily Load (TMDL) projects will be conducted over the next several years. TMDLs for nitrogen and phosphorus have been established for Swan Creek.

During the years 1985 to 2000, one long term monitoring station (WT1.1) in the tidal Bush River shows trends for two parameters -- long term measurements for both total phosphorus and algae abundance suggest a worsening of conditions. All other long term water quality measurements at this station show no significant trend (total nitrogen, dissolved oxygen, total suspended solids and water clarity as measured by secchi disk).

Land Use

Land in the Bush River Basin has significant concentrations of development. Overall, the River Basin is about 35% developed. The most developed 8-digit watershed is Bynum Run (53% developed) and the least developed is Bush River (nearly 25%).

Agriculture is a significant land use across the Bush River Basin except for Aberdeen Proving Ground. Agricultural land use involved 16 to 40% of the land in the other 8-digit watersheds.

Overall, forest land covers more than one third of the Bush River Basin. Large concentrations of forest are found in the Aberdeen Proving Ground and Bush River watersheds. Relatively little remains in the Bynum Run and Atkisson Reservoir watersheds (about 23 and 28% respectively).

Wetlands cover large acreage of Aberdeen Proving Ground (about 16%) and significant acreage in the Bush River 8-digit watershed (over 7%).

Compared to other Bush River Basin watersheds, Bynum Run watershed has the highest percent developed land and greatest extent of land identified for Smart Growth in a Priority Funding Area. It also has the least protected land and forest interior.

Living Resources and Habitat

The Upper Chesapeake Bay is considered to be very important for fish spawning and nursery. Estuarine areas of the Bush River Basin may contribute to the overall productivity of the area but specific information on Bush River Basin fisheries is not available. In nontidal streams, about half of the fish populations assessed by the Maryland Biological Stream Survey (MBSS) were rated as good and most of remainder were rated fair or poor. MBSS sites rated as very poor were all within the Aberdeen Proving Ground watershed. Fish consumption advisories have been issued for two tidal fish species (channel catfish and white perch) due to PCBs and pesticides and for some species commonly taken from lakes due to methyl-mercury.

In nontidal streams, benthic populations assessed by the MBSS across the Bush River Basin were commonly rated fair or poor. Locations assessed by MBSS as good were all found in the Swan Creek watershed. In the Aberdeen Proving Ground watershed, most areas assessed were rated as very poor.

Sensitive species areas identified for project review purposes are found in all of the 8-digit watersheds in the Bush River Basin. However, Wetlands of Special State Concern, which are subject to regulatory review requirements for sensitive species, are concentrated in a few areas: Bush River Watershed (Otter Point Creek, North of Sod Run, Church Creek), Atkisson Reservoir, and Swan Creek watershed (Swan and Gasheys Creeks, Chesapeake Bay shore area, Swan Harbor Farm Park). Habitat for the Federally Endangered Maryland Darter is located in the Swan Creek watershed (Gashey's Run).

Submerged aquatic vegetation (SAV) populations in the Bush River are very sparse compared to the potential physical habitat. The factors inhibiting SAV locally are believed to be associated with poor light penetration, elevated algal populations, nutrients and suspended solids.

Restoration Targeting Tools

Otter Point Creek in the Bush River watershed is designated as part of the National Estuarine Research Reserve. This designation provides for protection of over 900 acres of water, wetlands and uplands. The designation has also fostered long term efforts for estuarine research, monitoring and education relating to the local estuary.

DNR conducted a stream corridor assessment on Church Creek in 2002. This information augments earlier work by DNR on Bynum Run and Swan Creek and by Harford County in other Bush River Basin watesheds. These surveys identify the status of stream buffers, stream bank erosion and other measures of stream condition. This information provides a ground-truthed foundation for targeting restoration projects.

Computerized mapping was used to demonstrate concepts for restoration targeting and to help identify areas for additional site investigation for restoration of stream buffers and wetlands. For example, one GIS scenario suggests that opportunities for stream buffer restoration targeted to areas of poorly drained hydric soils to maximize nutrient uptake may be found upstream of Bel Air and in several headwater streams in the Bush River watershed.

CONTRIBUTORS TO THE WATERSHED CHARACTERIZATION

Harford County	Director of Department of Public Works Department of Public Works, Water Resources Engineering Department of Public Works, Water and Sewer Department of Planning and Zoning Department of Parks and Recreation Health Department
Maryland Dept. of Natural Resources (DNR)	Chesapeake and Coastal Watershed Service Coastal Zone Management Division Watershed Restoration Division Watershed Management and Analysis Division Chesapeake Bay National Estuarine Research Reserve Fisheries Service Resource Assessment Service Upper Western Shore Tributary Team
Others	Aberdeen Proving Ground U.S. Army Environmental Center Maryland Department of Agriculture Maryland Department of the Environment Maryland Department of Planning

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INTRODUCTION

Watershed Selection

Maryland's Clean Water Action Plan, completed in 1998, identified water bodies that failed to meet water quality requirements. As part of the State's response, the Maryland Department of Natural Resources (DNR) is offering funding and technical assistance to Counties willing to work cooperatively to devise and implement a Watershed Restoration Action Strategy (WRAS) for the impaired water bodies.[1,2] Harford County is one of five Counties participating in the second round of the WRAS program.

Location

The Bush River Basin is located entirely within Harford County, Maryland as shown in Map 1 Regional Context. Harford County encompasses the entire WRAS area as Map 2 WRAS Project Area shows. Additionally, Map 3 Streams and Sub-Watersheds and the adjacent table, indicate that five subwatersheds covering about 120,000 acres in the Bush River Basin are included in the WRAS project area.

Bush River Basin Acreage Summary (MDP 2000 Land Use rounded to nearest acre)

Subwatershed	Land	Water	Total
Bush River	36,967	8,870	45,837
Lower Winters Run	8,399	69	8,468
Atkisson Reservoir	29,021	55	29,076
Bynum Run	14,577	6	14,583
Aberdeen PG	19,780	1,845	21,625
Swan Creek	16,131	731	16,862
Watershed Total	124,875	11,576	136,451
WRAS Area Total	108,744	10,845	119,589

Two of the subwatersheds addressed in this report area not tributary to the Bush River but they are within the State-designated area for the Bush River Basin ("6-digit" watershed): Aberdeen PG is included because it is part of the County's WRAS project area. Swan Creek is not part of the County's WRAS project area but it is included to allow comparison of subwatersheds across the entire Bush River Basin.

Purpose of the Characterization

One of the earliest steps toward devising a Watershed Restoration Action Strategy is to characterize the watershed using immediately available information. This Watershed Characterization is intended to meet several objectives:

– briefly summarize the most important or relevant information and issues

– provide preliminary findings based on this information

– identify sources for more information or analysis
– suggest opportunities for additional characterization and restoration work.

Additional Characterization Recommended

The Watershed Characterization is intended to be one starting point. It is part of a framework for a more thorough assessment involving an array of additional inputs:

– self-investigation by the local entity
– targeted technical assistance by partner agencies or contractors
– input from local stakeholders
– Stream Corridor Assessment, i.e. physically walking the streams and cataloguing important issues, is part of the technical assistance offered by DNR
– Synoptic water quality survey, i.e. a program of water sample analysis, can be used to focus on local issues like nutrient hot spots, point source discharges or other selected issues. This is also part of the technical assistance offered by DNR.

Identifying Gaps in Information

It is important to identify gaps in available watershed knowledge and gauge the importance of these gaps. One method is to review available information in the context of four physical / biological assessment categories that have been successfully applied in other watershed restoration efforts. These are the main categories that impact aquatic biota:

– Habitat: physical structure, stream stability and biotic community (including the riparian zone)
– Water Quantity: high water - storm flow & flooding; low water - baseflow problems from dams, water withdrawals, reduced infiltration
– Water Quality: water chemistry; toxics, nutrients, sediment, nuisance odors/scums, etc.
– Cumulative effects associated with habitat, water quantity and water quality.

Adaptive Management

In addition, the Watershed Characterization and the Watershed Restoration Action Strategy should be maintained as living documents within an active evolving restoration process. These documents will have to be updated periodically as new, more relevant information becomes available and as the watershed response is monitored and reassessed. This type of approach to watershed restoration and protection is often referred to as "adaptive management."

WATER QUALITY

Priority for Restoration and Protection

The 1998 *Maryland Clean Water Action Plan* established priorities for watersheds in the State water quality restoration and protection. In the Plan, Category 1 Priority watershed (highest State priority for restoration) was applied to three subwatersheds in the Bush River basin as shown in Map 4 Category 1 Priority Watersheds:

- Bush River, watershed 02130701
- Bynum Run, watershed 02130704
- Swan Creek, watershed 02130706 (outside of the WRAS project area)

As the basis for the prioritization, indicators of water quality, landscape and living resources were developed for all watersheds in Maryland. These indicators are described in greater detail in separate sections in this watershed characterization.

Designated Uses

All waters of the State are assigned a "Designated Use" in regulation, COMAR 26.08.02.08, which is associated with a set of water quality criteria necessary to support that use. Map 5 Designated Uses shows the distribution of designated uses across the Bush River Basin. In the simplified summary below, designated uses requiring the better water quality are listed first and the least restrictive (Use I) is listed last. In general, Use I water quality requirements apply everywhere unless superceded by criteria necessary for other designated uses. (The Department of the Environment should be contacted for official regulatory information.) [3]

- Use III Natural Trout Waters: Bynum Run and all tributaries
- Use IV-P Recreational Trout Waters and Protection of Public Water Supply:
  Winters Run and all tributaries
- Use II Shellfish Harvesting: All estuarine portions of tributaries except:
  (a) Bush River and tributaries above a line from Fairview Pt. to Chillbury Pt.
  (b) Romney Creek above Briar Point
  (c) Swan Creek and tributaries above mouth
- Use I-P Water Contact Recreation, Protection of Aquatic Life and Protection of Public Water Supply: Winters Run and all tributaries, including Atkisson Reservoir from Otter Point Creek to upstream boundary of Atkisson Reservoir.
- Use I Water Contact Recreation and Protection of Aquatic Life: All water bodies not otherwise designated above.

Not Supporting Designated Use – 303(d) Listings

The table 303(d) List of Impaired Waters shows that there are 13 listings within the Bush River Basin. These listings mean that pollution associated with nutrients, suspended sediment and/or toxic materials are preventing full use of these waters based on State criteria.

A statewide assessment of water quality is required under Section 303(d) of the Federal Clean Water Act. As part of the assessment, Maryland tracks waterways that do not support their designated use in a list of "impaired waters" and in a prioritized list of "Water Quality Limited Basin Segments" also known as the 303(d) priority list. Information considered in setting the 303(d) list priorities include, but is not limited to, severity of the problem, threat to human health and high value resources, extent of understanding of problem causes and remedies.[5]

Each impairment identified in the 303(d) List is assigned a priority which is intended to help communicate the need for correcting the impairment relative to all impairments listed Statewide. Waterways with impairments having the greatest potential impacts to human health, high value resources, etc. are ranked numerically 1 through 25. All other impairments that are not ranked in the top 25 are ranked high, medium or low.

Potential Next Steps. A potential goal for a WRAS could be elimination of 303(d) listings for the watershed and/or mitigation of the causes contributing to the listings.

Shellfish Harvesting Restrictions

As shown in Map 5 Designated Uses, a large portion of the Bush River are designated for shellfish harvesting. However, the entire area shown as Use II waters for shellfish harvesting on the map is "restricted." This restriction applied by the Maryland Department of the Environment (MDE) "means that no harvesting of oysters and clams is allowed at any time."

Use II (shellfish harvesting waters in this basin are technically restricted because only minimal monitoring is being done due to the lack of a commercially harvestable resource.[26]
There are relatively few oysters in the Bush River because it typically has less than 0.5 parts per thousand (ppt) salinity but oysters grow best in water with greater than 12 ppt. Consequently, the State's shellfish area monitoring efforts are not invested in low salinity areas like the Bush River where oysters can not be commercially harvested. In the absence of regular monitoring, the restriction is necessary to protect human health because oysters and clams are filter feeders that are readily contaminated by even brief or intermittent exposure to animal and human waste.

303(d) List of Impaired Waters for the Bush River Basin[4] from *2000 Maryland Section 305(b)Water Quality Report, Appendix F*				
Watershed	**Number**	**Impairment**	**Sources**	**Priority**
Bush River: Cranberry Run & Broad Run	02130701 -1129	Biological	Unknown	low
Bush River	02130701	Nutrients	NPS, natural	low
		Suspended Sediment	NPS, natural	low
Winters Run	02130702	impairment not listed		
Atkisson Reservoir	02130703	Nutrients	NPS, natural	low
		Suspended Sediment	NPS, natural	low
Bynum Run	02130704	Nutrients	NPS, natural	low
		Suspended Sediment	NPS, natural	low
Aberdeen Proving Ground	02130705	Toxic Substances	NPS, natural	18
		Nutrients	Point Source, NPS, natural	low
		Suspended Sediment	Point Source, NPS, natural	low
		Toxic Substances	Point Source, NPS, natural	low
Swan Creek	02130706	Nutrients	NPS, natural	low
		Suspended Sediment	NPS, natural	low

Total Maximum Daily Loads

The Maryland Department of the Environment (MDE) uses the 303(d) priority list to help set State work schedules for various programs including establishment of Total Maximum Daily Loads (TMDLs). The intent of establishing one or more TMDLs for a water body is to estimate a pollutant load that the water body can assimilate and still meet water quality standards. Then a waste load allocation is generated to identify appropriate pollution reduction needs among current pollutant sources.

Based on January 2002 work load projections, MDE has set several target years for establishing TMDLs for water bodies in the Bush River watershed. (Note 1: work load scheduling is subject to change. Note 2: In the table, NPS means nonpoint sources from human activity.):

TMDL Summary for the Bush River Basin				
Watershed	Impairment	Target Yr	TMDL ID	TMDL Status
Bush River	Sediment	2008	02130701SBR	future
Atkisson Reservoir	Nutrients	2002	02130703NAR	future
	Sediment	2008	02130703SAR	future
Bynum Run	Nutrients	2002	02130704NBR	future
	Sediment	2008	02130704SBR	future
Aberdeen Proving Ground	Nutrients	2004	02130705NAPG	future
	Sediment	2008	02130705SAPG	future
	Toxic Substances	2003	02130705ToxAPG	future
Swan Creek (not in WRAS)	Nutrients	2003	02130706NSC	final 3/2002 for nitrogen, phosphorus
	Sediments	2008	02130706SSC	future

In general, TMDLs include several key parts:

1- Existing conditions for pollutant loads (pounds per day) and pollutant sources.

2- Maximum pollutant load that the water can accept and while still allowing the water body to meet its intended use.

3- Allocation of the maximum pollutant load (#2 above) to specific pollutant sources.

Why Are Local Waters Impaired?

Biological. Within selected stream segments, populations of benthic macroinvertebrates and fish and their associated physical habitat have been assessed by the Maryland Biological Stream Program. Based on criteria developed for each physiographic/ecological zone in Maryland, each stream segment is rated as either good, fair, poor or very poor. Ratings of poor and very poor were listed as biological impairment for the first time in Maryland in the draft 2002 303(d) list of impaired waters.

Nutrients. In Maryland, most water bodies naturally have low levels of the nutrients nitrogen or phosphorus. These nutrients enter waterways from all types of land and from the atmosphere. Nutrient pollution or over-enrichment problems may arise from numerous sources. For example, residential land can be an important contributor of nutrients depending on fertilizer use, extent of lawn and the status of septic systems. Many farmers carefully manage nutrients using different approaches, so nutrients entering waterways from crop land varies greatly depending on management techniques. Typically, smaller amounts of nutrients reach surface waters from an acre of forest land than from an acre of other types of land. The atmosphere can contribute various forms of nitrogen arising from the burning of fossil fuels in power plants and from automobile exhaust.

Suspended Sediment. Most unpolluted streams and tidal waters naturally have limited amounts of sediment moving "suspended" in the water. Excessive amounts of suspended sediment in waterways are considered pollution because they can inhibit light penetration, prevent plant growth, smother fish eggs, clog fish gills, etc. Sediment in streams tends to arise from stream bed and bank erosion and from land that is poorly vegetated or disturbed. Suspended sediment pollution may arise from construction sites, crop land, bare ground and exposed soil. The amount of sediment contributed varies greatly site to site depending upon stream stability, hydrology, management controls and other factors.

Toxic Substances. A wide array of materials may be considered toxic substances because they exhibit poisonous or lethal affects or otherwise harm aquatic life. These materials are very diverse in their sources and effects. Sometimes toxic substances can occur naturally. However, toxic substances of concern for water quality restoration are those types that are the product of human activity. For regulatory purposes, the US Environmental Protection Agency maintains a list of substances that are considered to be toxic. A few examples are heavy metals, polychlorinated biphenyls (PCBs), asbestos and many other materials.

National Academy Press, Clean Coastal Waters (2000)
What Are the Effects of Nutrient Over-Enrichment? [6]

The productivity of many [lake, estuary and] coastal marine systems is limited by nutrient availability, and the input of additional nutrients to these systems increases primary productivity [microscopic organisms including algae]. In moderation in some systems, nutrient enrichment can have beneficial impacts such as increasing fish production; however, more generally the consequences of nutrient enrichment for coastal marine ecosystems are detrimental. Many of these detrimental consequences are associated with eutrophication.

The increased productivity from eutrophication increases oxygen consumption in the system and can lead to low-oxygen (hypoxia) or oxygen-free (anoxic) water bodies. This can lead to fish kills as well as more subtle changes in ecological structure and functioning, such as lowered biotic diversity and lowered recruitment of fish populations.

Eutrophication can also have deleterious consequences on estuaries even when low-oxygen events do not occur. These changes include loss of biotic diversity, and changes in the ecological structure of both planktonic and benthic communities, some of which may be deleterious to fisheries. Seagrass beds and coral reefs are particularly vulnerable to damage from eutrophication and nutrient over-enrichment.

Harmful algal blooms (HABs) harm fish, shellfish, and marine mammals and pose a direct public health threat to humans. The factors that cause HABs remain poorly known, and some events are entirely natural. However, nutrient over-enrichment of coastal waters leads to blooms of some organisms that are both longer in duration and of more frequent occurrence.

Although difficult to quantify, the social and economic consequences of nutrient over-enrichment include aesthetic, health, and livelihood impacts.

Water Quality Indicators

The Clean Water Action Plan's 1998 *Unified Watershed Assessment* established priorities for watersheds in the State for restoration and protection. In the Plan, three watersheds in the Bush River Basin watershed were listed for action under the highest priority for restoration (Category 1 Priority):

– Bush River 02130701
– Bynum Run 02130704
– Swan Creek 02130706

As the basis for the prioritization, indicators of water quality, landscape and living resources were developed for all watersheds in Maryland. Other approaches to assessing water quality have been in use for several years and are further described below. In general they do not look comparatively at watersheds as the Unified Assessment did in an effort to set priorities. The Unified Assessment also considered a range of living resource and landscape indicators described a little later.

The Unified Assessment used water quality indicators to compare the State's 138 watersheds which were applied to help characterize the Bush River Basin. The findings for the water quality indicators are summarized in the table below and are more thoroughly explained in the following text.

Water Quality Indicator	Bush River	Lower Winters Run	Atkisson Reservoir	Bynum Run	APG	Swan Creek
State 303(d) List Impairment Number	2	0	2	2	2	2
Modeled TN Load	27.88	11.54	9.18	10.94	9.32	15.28
Modeled TP Load	1.14	0.38	0.49	0.47	0.32	0.67
Tidal Habitat Index	4.3					
Tidal Eutrophication Index	7.0					

NOTES: Click on the indicator name to link to its description and interpretation.

Unshaded indicators in the table mean that average watershed conditions measured by this indicator are better than the Statewide benchmark.

Shaded indicators grid mean that average watershed conditions measured by this indicator are worse than the Statewide benchmark, i.e. water quality problems are more likely to arise due to the conditions represented by the indicator.

1. State 303(d) Impairment

In the Bush River Basin, all of the watersheds in the Basin are on the 303(d) list with the exception of Lower Winters Run. For this indicator, presence on the 303(d) list means that the following watersheds have one or more water quality problems that need correction or restoration: Bush River, Atkisson Reservoir, Bynum Run, Aberdeen Proving Ground and Swan Creek.

2. Modeled Total Nitrogen Load

For the Bush River Basin, the total nitrogen (TN) load reaching the Chesapeake Bay was estimated using a computer model to be relatively low for Atkisson Reservoir and Aberdeen Proving Ground watersheds. Compared to other watersheds draining to the Chesapeake Bay in Maryland, these watersheds ranked among those transporting less TN to the Chesapeake Bay.

All the other watersheds in the river basin has relatively high estimated total nitrogen loads reaching the Chesapeake Bay. Compared to other watersheds draining to the Chesapeake Bay in Maryland, the Bush River, Lower Winters Run, Bynum Run and Swan Creek watersheds ranked among those transporting high TN to the Chesapeake Bay.

Nitrogen Load is a measure of how much of this important nutrient reaches streams and other surface waters. For each type of land use in the watershed, on average, stormwater tends to carry or transport a characteristic amount of nitrogen from the land to nearby streams. Based on these averages, computers can be used to estimate (model) how much nitrogen is likely to be reaching Chesapeake Bay. The Chesapeake Bay is receiving too much nitrogen, so higher TN loads from watersheds contribute to the water quality problems in the Chesapeake Bay.

To create a benchmark for this indicator, the modeled TN loads for the 8-digit watersheds draining to the Chesapeake Bay were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. Four watersheds in the Bush River Basin (Bush River, Lower Winters Run, Bynum Run and Swan Creek) exceeded this benchmark.

3. Modeled Total Phosphorus Load

For the Bush River Basin, the total phosphorus (TP) load reaching the Chesapeake Bay was estimated using a computer model to be relatively low for four watersheds: Lower Winters Run, Atkisson Reservoir, Bynum Run and Aberdeen Proving Ground. Compared to other watersheds draining to the Chesapeake Bay in Maryland, these watersheds ranked among those transporting less TN to the Chesapeake Bay.

The TP load reaching the Chesapeake Bay from two Bush River Basin watersheds was estimated to be relatively high according to the computer model. Compared to other Chesapeake Bay watersheds in Maryland, the Bush River and Swan Creek watersheds ranked among those transporting high TP to the Chesapeake Bay.

Total Phosphorus is a measure of how much of this important nutrient is reaching streams and other surface waters. The ranking for modeled TP Load was performed in parallel to the ranking for modeled TN Load above. The Chesapeake Bay is receiving too much phosphorus, so higher TP loads from watersheds contribute to the water quality problems in the Chesapeake Bay.

To create a benchmark for this indicator, the modeled TP loads for the 8-digit watersheds draining to the Chesapeake Bay were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. The Bush River and Swan Creek watersheds did exceeded this benchmark.

4. Tidal Habitat Index

In the Bush River Basin, the Bush River watershed had sufficient data available to be assessed for the Tidal Habitat Index. The other two watersheds in the Basin that include tidal waters, Aberdeen Proving Ground and Swan Creek, did not have sufficient data for assessment.

Compared to other Chesapeake Bay watersheds in Maryland, the Bush River watershed ranked among those having poorer tidal habitat based on an index combining three measurements of water quality: algae populations as measured by surface chlorophyll *a*, water clarity as measured by secchi depth and summer bottom dissolved oxygen (July-Sept.). Using data collected 1994-1996, the Bush River watershed ranked "4.3" on a scale of 1(worst) to 10(best).

To create a benchmark for this indicator, the index scores for the 8-digit watersheds draining to the Chesapeake Bay were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the lowest quartile (25% of the watersheds) "exceeded" the benchmark. The Bush River watershed exceeded this benchmark.

5. Tidal Eutrophication Index

In the Bush River Basin, the Bush River watershed had sufficient data available to be assessed for the Tidal Eutrophication Index. The other two watersheds in the Basin that include tidal waters, Aberdeen Proving Ground and Swan Creek, did not have sufficient data for assessment.

Compared to other Chesapeake Bay watersheds in Maryland, the Bush River watershed ranked among those having less eutrophication problems based on an index combining of three measurements of water quality (in surface mixed-layer water): total nitrogen, total phosphorus and total suspended solids. Using data collected 1994-1996, the Bush River watershed ranked "7.0" on a scale of 1(worst) to 10(best).

To create a benchmark for this indicator, the index scores for the 8-digit watersheds draining to the Chesapeake Bay were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the lowest quartile (25% of the watersheds) "exceeded" the benchmark. The Bush River watershed did not exceed this benchmark.

Water Quality Background 1950s to 1988

Slow flushing characteristics of the Bush River tend to accentuate water quality problems there. It typically takes 48 days for this tidal fresh estuary to flush.[8] Salinity in the tidal Bush River varies from about 5 parts per thousand (ppt) at the Chesapeake Bay to about 0.1 ppt in the upper Bush River to less than 0.05 ppt at the mouths of tributary creeks like Otter Point Creek.[14]

1. Tidal Bush River

The earliest available water quality records covering the 1950s through 1965 noted high bacteria levels in the tidal Bush River. This a period before public sewerage services were offered in the Bush River watershed. The sources of this bacterial problem were believed to be existing discharges directly into the river including Bata Shoe, Edgewood Arsenal and probably effluent from private septic systems. Sampling in 1965 verified high bacterial populations in the river including E. Coli. These high bacterial populations were found in extensive areas of the upper tidal reaches of the Bush River and along the western shore of the Bush River toward the Chesapeake Bay.[11]

1970s and 1980s In General

Bacteria problems began to cause swimming closures in the Upper Bush River beginning in 1971. These problems were in-part associated with failing septic systems.[8] Several projects gathered water quality data in the 1970s and 1980s:

1972	Goucher College Environmental Studies Program had sampling stations in the open tidal waters of the Bush River and near the mouths of Bush Creek and Cranberry Run.[9]
1977	DNR had sampling stations in the tidal waters of the Bush River[9]
1980-82	CH2M Hill, a consultant working for Harford County had most sampling stations in open tidal waters of the Bush River with the exception of two stations near the tidal interface in Otter Point Creek and James Run.[9]
1987	Harford County Dept. Of Public Works[10]
1988	Harford Community College[12]

Dissolved oxygen (DO) concentrations measured at all stations by CH2M Hill and DNR were higher than the minimum standard of 5.0 mg/l. However, 1972 dissolved oxygen sampling data showed several DO standard violations near the mouths of Bush Creek and Cranberry Run.[9] In 1987, DO concentrations below the standard were recorded at Church Creek, the upper Bush River and Otter Point Creek.[10] Additional DO problems were reported in 1988 for Greys Run, Cranberry Run and Bynum Run.[12]

High fecal coliform bacteria populations were found by DNR in July 1977 up and down the tidal Bush River. 1982 monitoring by CH2M Hill found the highest fecal coliform bacteria populations and biochemical oxygen demand (BOD) tended to be from their two stream stations. The next highest findings were found near Otter Point.[9] Specific sources of these problems were believed to be associated with remaining failing septic systems even though about one-half of the watershed's population was now served by public sewer service.[8] 1987 sampling found four sites with fecal coliform bacteria greater than 200 MPN (most probable number): 2 stations in the upper Bush River, Winters Run at Rt 40 and James Run at Rt 40. Additionally, Bynum Run and Church Run were considered likely contributors.[10] Winters Run was identified again for a high fecal coliform count in 1988.[12]

Algae blooms reported in the upper tidal Bush River were believed to be driven by nutrient inputs from tributary streams.[9] In 1987, algae blooms in the upper Bush River north of the AMTRAK railway bridge was identified as a continuing issue.

Nutrient concentrations in the tidal Bush River were high. For total phosphorus, concentrations

greater than 0.01 mg/l were considered to highly enriched. Monitoring in 1972-73 for DNR Power Plant Siting found total phosphorus concentrations were nearly always greater than this benchmark with peak concentrations between 0.05 and 0.07 mg/l.[19] 1987 monitoring data found that the orthophosphorus fraction alone averaged between 0.04 and 0.08 mg/l.[10]

For total inorganic nitrogen (which is collectively ammonia, nitrite and nitrate), concentrations greater than 0.5 to 1.5 mg/l were considered very high. 1972-73 data gathered for the DNR Power Plant Siting Program found organic nitrogen concentrations occasionally above 0.5 mg/l.[19] Monitoring data found that ammonia nitrogen ranged from 0.01 to 0.11 mg/l and nitrate nitrogen ranged from 0.02 to 0.77 mg/l. Data for the two streams sampled supported the belief that tributary streams were a significant nutrient source for the Bush River. Additionally, 1972 data collected by the Goucher College Environmental Studies Program reported high nutrient concentrations near the mouths of Bush Creek and Cranberry Run. In 1987, high nutrient concentrations tended to found at all sampling sites.[10] In 1988, elevated nutrients were found at all sampling sites including Bynum Run, James Run, Greys Run and Cranberry Run. Additionally, a trend toward increasing nitrate concentrations was reported.[12]

Sedimentation problems were believed to be associated with urbanizing areas of the watershed.[9] High sediment loads were reported in Lower Winters Run.[8] The County Dept. of Public Works identified several streams as the major sources of sediment to the upper Bush River in 1987: Otter Point Creek, James Run/Bynum Run, and Church Creek. Then, again in 1988, turbidity levels exceeding the State standard were reported for Bynum Run (the highest), Winters Run and James Run.

2. Atkisson Reservoir[13]

During the 1970s, excessive sediment movement in streams above the Reservoir was known to be a problem based on water intake records maintained by Maryland Water Works. Sampling in 1980 in the 38-year old Atkisson Reservoir found that 81% of its original volume had been lost to deposited sediment. That same year, stream surveys conducted upstream of the Reservoir found excessive sediment in Winters Run and Plum Tree Run near the Reservoir. However, turbidity in the reservoir in 1980 was not found to be a problem. [These findings may suggest that sediment mobilized upstream of the Reservoir tended to be larger particles that readily settled out in slack water, ed.]

The Reservoir was characterized as eutrophic with algae blooms commonly occurring in summer. The blooms were believed to be caused by high total phosphorus concentrations in the Reservoir ranging from 0.07 to 0.52 mg/l. At the time, EPA criteria was 0.025 mg/l total phosphorus.

Low dissolved oxygen concentrations were identified in deep waters of the Reservoir below the 13 foot depth.

Bacterial problems in the Reservoir were identified in the 1960s and 1970s. Sampling in 1980 verified that fecal coliform counts were typically high.

Temperature, pH, metals or pesticides were not identified as concerns in the Reservoir.

Water Quality Assessment 1989 to the Present

In the Bush River Basin (021307), there is one regularly scheduled long-term water quality monitoring effort for one station (WT1.1) in the tidal Bush River. All other monitoring is short term and special purpose. For example, the Maryland Biological Stream Survey collects water quality information in nontidal streams as part of its program. Additionally, MDE collected water quality data in 1999 to support permitting decisions and anticipated work on Total Maximum Daily Loads (TMDLs).[26]

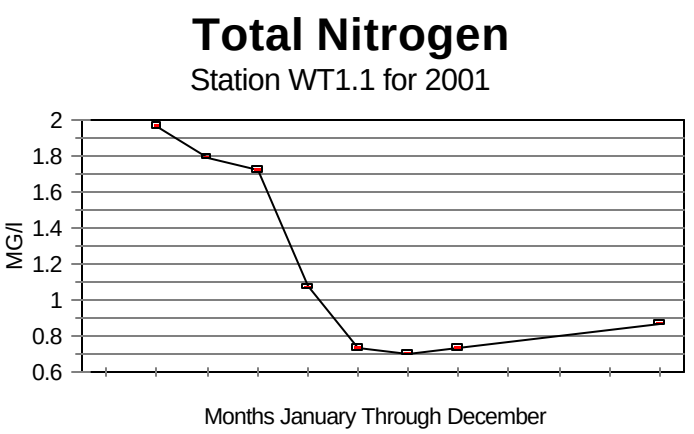
Cheseapeake Bay Program Tributary Monitoring Station WT1.1 shown on Map 6 Monitoring Stations is the best source of long term water quality data for the tidal Bush River. DNR Resource Assessment Service has analyzed data from this station and a summary of their findings appears in the table below. The status for each parameter in the table is a relative ranking at three levels: good, fair and poor. For example, the ranking of "fair", which is the most common ranking in the table, means that the Bush River ranking is fair compared to comparable Chesapeake Bay tributaries with comparable salinity. Additional discussion follows the table in this section. A more detailed look at the historic water quality record for this monitoring station is presented in Appendix A Selected Water Quality Historic Record for Bush River Station WT1.1.

As part of DNR's work of the Upper Western Shore Tributary Team, this relative water quality assessment for the tidal Bush River and nearby tidal tributaries is presented in DNR's Internet site www.dnr.state.md.us/bay/tribstrat/index.html. [1, 9] For additional information on water quality in general and Station WT1.1 specifically, see http://www.chesapeakebay.net/wquality.htm and www.dnr.state.md.us/irc/datasets.html

Parameter	**Status 1998 -2000 data**	**Trend 1985 through 2000**
Nitrogen: total	Fair	No Trend
Phosphorus: total	Fair	Degrading (46%)
Algae: Abundance	Poor	Degrading (117%)
Dissolved Oxygen (summer, bottom waters)	Good	No Trend
Water Clarity: secchi depth	Poor	No Trend
Suspended Solids: total	Fair	No Trend

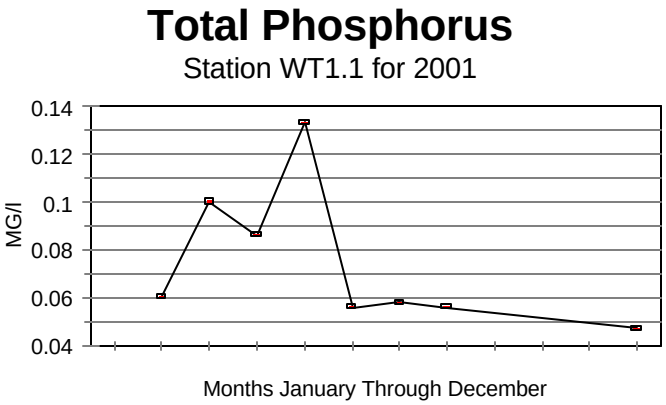
1. Nitrogen

Total nitrogen concentrations for 1998 through 2000 from station WT1.1 in the Bush River suggested "fair" water quality. For the period 1985 through 2000, there was no trend toward significant change. During 2001, the graph shows total nitrogen concentrations varied slightly more than 1 mg/l averaging 1.2 mg/l for the year.



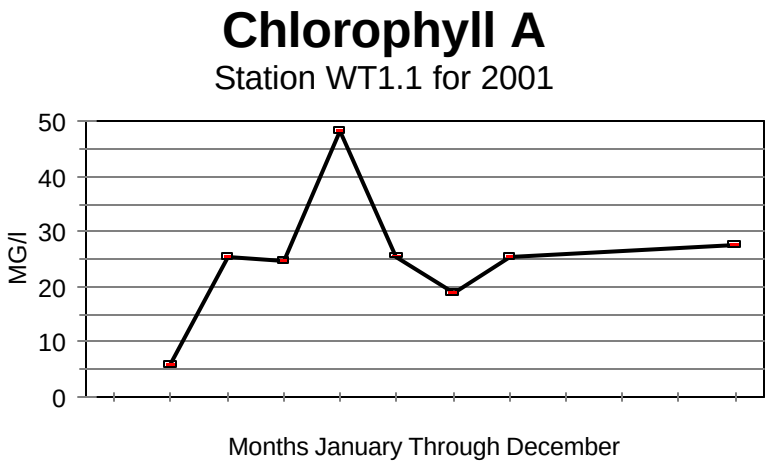
2. Phosphorus

Total phosphorus concentrations for 1998 through 2000 from station WT1.1 in the Bush River suggested "fair" water quality. For the period 1985 through 2000, there was a trend toward increasing concentrations suggesting worsening conditions. During 2001, the graph shows total phosphorus concentrations varied about than 0.1 mg/l averaging 0.074 mg/l for the year.



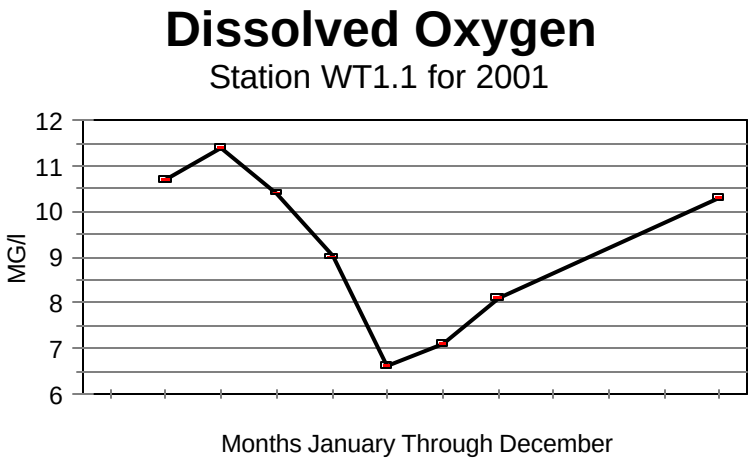
3. Algae

Abundance of algae as measured by chlorophyll *a* concentrations for 1998 through 2000 from station WT1.1 in the Bush River suggested "poor" water quality. For the period 1985 through 2000, there was a trend toward increasing concentrations suggesting worsening conditions. During 2001, the graph shows total nitrogen concentrations varied more than 40 *u*g/l averaging about 25 micrograms per liter (*u*g/l). The year 2001 average chlorophyll *a* concentrations suggest that algae abundance is typically high enough to inhibit health of submerged aquatic vegetation during the growing season.

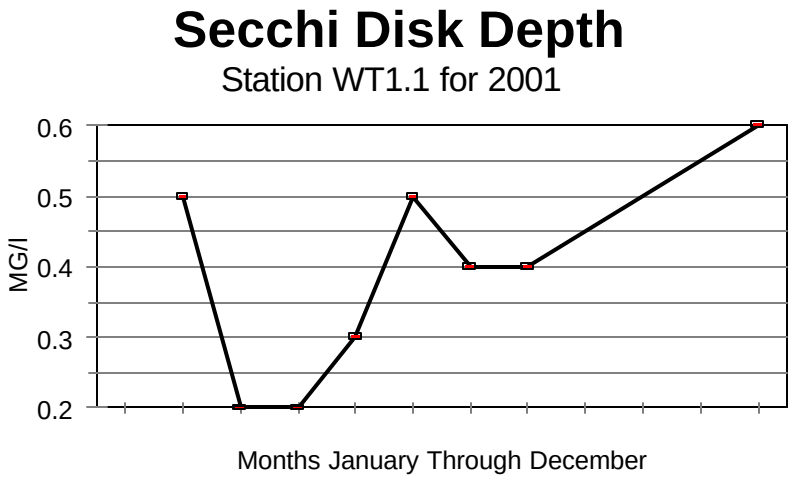


4. Dissolved Oxygen

Dissolved oxygen concentrations for 1998 through 2000 from station WT1.1 in the Bush River suggested "good" water quality. For the period 1985 through 2000, there was no trend toward significant change. During 2001, the graph shows dissolved oxygen concentrations varied about 5 mg/l averaging 9.2 mg/l for the year. Measurements at this station have consistently met the State water quality standard of 5.0 mg/l during the past several years. Data collected from this station, due to its location in the middle of the Bush River's open tidal waters, probably does not reflect dissolved oxygen conditions in tidal waters in more restricted areas.

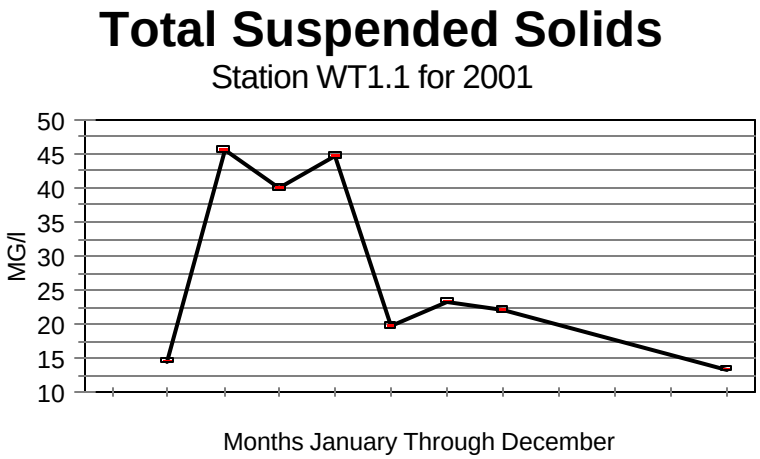


5. Water Clarity



The measurement of water clarity for 1998 through 2000 at station WT1.1 in the Bush River using secchi disk depth suggested "poor" water quality. For the period 1985 through 2000, there was no trend toward significant change. During 2001, the graph shows secchi disk depth varied less than one half meter averaging 0.4 meters for the year. Measurements from this station indicate that water clarity is too limited to support submerged aquatic vegetation. However, water clarity conditions in other parts of the tidal Bush River may differ significantly.

6. Suspended Solids



Total suspended solids concentrations for 1998 through 2000 from station WT1.1 in the Bush River suggested "fair" water quality. For the period 1985 through 2000, there was no trend toward significant change. During 2001, the graph shows total suspended solids concentrations varied about 30 mg/l averaging 28 mg/l for the year.

7. Chemical Contaminants

Overall, the Bush River is identified by the US EPA Chesapeake Bay Program as an area with insufficient or inconclusive data.[30] Sampling of sediment and the water column in the Bush River has not been conducted to support a more definitive statement. However, limited data in the Aberdeen Proving Ground watershed has identified toxic substances of concern in small areas. Additionally, the most recent Fish Consumption Advisory from the Maryland Dept. of the Environment identified PCBs, pesticides and methyl mercury in fish tissue as concerns.

Point Sources

Discharges from discrete conveyances like pipes are called "point sources." Point sources may contribute pollution to surface water or to groundwater. For example, waste water treatment discharges may contribute nutrients or microbes that consume oxygen (measured as Biochemical Oxygen Demand (BOD) that reduce oxygen available for aquatic life. Stormwater discharges may contribute excessive flow of water and/or seasonally high temperatures. Industrial point sources may contribute various forms of pollution. Some understanding of point source discharges in a watershed targeted for restoration is useful in helping to prioritize potential restoration projects.

Permit information from the Maryland Department of the Environment (MDE) permit data base for the Bush River basin is summarized in the table below and on Map 7 MDE Permits.

Characteristics of the these permitted discharges (volume, temperature, pollutants, etc.) are tracked by MDE through the permit system. Most of this information is accessible to the public and can be obtained from MDE.

MDE Permit Summary Bush River Basin					
Watershed(s)	Surface Water NPDES	Stormwater NPDES	Groundwater Discharge	General Permits	Total All Permits
Bush River 02130701	6	14	2	6	28
Lower Winters Run & Atkisson Reservoir	1	2	2	4	9
Bynum Run 02130704	--	3	1	3	7
APG 02130705	1	--	--	1	2
Swan Cr. 02130706	4	4	4	3	15
Bush River Basin Total	12	23	9	17	61

Note: Click on the watershed name for a listing of MDE permits in that watershed area.

MDE Permits Listing – Page 1 of 5 Bush River Watershed 02130701 Aberdeen Proving Ground 02130705 (Sept. 2001 data)			
Type / MDE Category	**Facility Name**	**Permit(s) MD/NPDES**	**Receiving Stream / Location**
Surface Water Discharge "Municipal Permits" (Sewage Treatment)	Sod Run WWTP	97DP1580 MD0056545	Bush River Chelsea Rd, Perryman
	US Army APG	97DP2531 MD0021229	Bush River
		97DP2532A MD0021237	
Surface Water Discharge "Industrial Permits"	Bata Shoe Company	96DP0139 MD0001431	Bush River, Pulaski Hwy, Belcamp
	Bottcher America Corp. (cooling water)	01DP3374	Unnamed tributary to Bush River, Belcamp
	Independent Can Co.	94DP2681 MD0064220	
	Price Brothers Co.	93DP0010 MD0001732	Cranberry Run Perryman Rd, Perryman
	US Army APG	96DP2517A MD0003565	Bush River
		97DP3242 MD0068012	
Groundwater Discharge "Industrial"	Bowmans Butcher Shop	95DP2471	Churchville Road, Aberdeen
	Constellation Power (oil contam. mitigation)	98OGR2086 MDG912086	Chelsea Rd, Perryman

MDE Permits Listing – Page 2 of 5 Bush River Watershed 02130701 Aberdeen Proving Ground 02130705 (Sept. 2001 data)			
Type / MDE Category	**Facility Name**	**Permit(s) MD/NPDES**	**Receiving Stream / Location**
Gen. Industrial Stormwater Permit	American Color Graphics	97SW0164	Unnamed tributary to Bush River, Belcamp
	Bottcher America Corp	97SW0487	
	Citrus And Allied Essences	97SW0188	
	Monarch Manufacturing	97SW0330	
	Tower Auto. Products	97SW0329	
	Johnson Controls	97SW0717	
	Clorox Products	97SW0999	Cranberry Run Aberdeen
	Frito-Lay	97SW0710	
	Crouse Construction	97SW0935	
	Independence Const. (asphalt plant)	97SW1023	
	York Building Products	97SW0866	
	Harford Co. Trans. Fac.	97SW1271	Otter Point Creek Abingdon Rd, Abingdon
	Maryland Paving (Churchville)	97SW1346	tributary to James Run Calvery Rd, Bel Air
	Maryland Paving (Aberdeen)	97SW0720	Grays Run Carsins Run Rd, Aberdeen

MDE Permits Listing – Page 3 of 5 Bush River Watershed 02130701 Aberdeen Proving Ground 02130705 (Sept. 2001 data)			
Type / MDE Category	**Facility Name**	**Permit(s) MD/NPDES**	**Receiving Stream / Location**
General Permits	Bush River Boat Works	96MA9132	Bush River, Perryman Rd.
	Davis Concrete	00MM2559 MDG492559	Romney Creek Old Phila. Rd, Aberdeen
	Flying Point Marina	96MA9187	Otter Point Creek, Edgewood
	Greenridge Utilities	00HT9526	Broad Run (trib to James Run) Fountain Green Rd, Belair
	Maryland Portable Concrete	00MM9701 MDG499701	Cranberry Run South Phila. Blvd., Aberdeen
	S&G Concrete	00MM2783 MDG492783	Otter Point Creek Phila. Rd, Edgewood
	Spencer S&G Rubble Fill	00MM9861 MDG499861	Otter Point Creek Abingdon Rd, Abingdon

1. Sod Run Waste Water Treatment Plant

The the Sod Run Waste Water Treatment Plant (WWTP) began operating in 1969 with a discharge to Romney Creek. By the late 1970s, the plant had expanded capacity from 4 million gallons per day (MGD) to 10 MGD. In October 1982, the discharge averaging about 5 MGD was moved to the Bush River in response to tightened discharge requirements for Romney Creek.[9]

In the Bush River watershed (02130701), the discharge from the Sod Run WWTP is the most important nutrient point source. For the year October 2000 to October 2001, the average effluent flow from the plant was 11 million gallons per day. The monthly average total phosphorus concentration for the period was 1.1 mg/l. For the same period, The monthly average total nitrogen concentration was 9.0 mg/l.[27]

MDE Permits Listing – Page 4 of 5 (Sept. 2001 data) Lower Winters Run Watershed 02130702 Atkisson Reservoir Watershed 02130703			
Type / MDE Category	**Facility Name**	**Permit(s) MD/NPDES**	**Receiving Stream / Location**
Surface Water / Industrial	Tollgate Landfill	96DP2887 MD0065765	Winters Run North Tollgate Road, Bel Air
Groundwater / Industrial	Jarrettsville Elementary	95DP1318	Norrisville Rd, Jarrettsville
	Village Volvo	96DP2890	Bel Air Rd, Bel Air
Gen. Industrial Stormwater Permit	Alcore, Inc.	97SW1247	Winters Run Edgewood
	Auto Wreckers	97SW0539	
General Permits	Daneker Sand & Gravel	00MM2282	Osburn Lane, Joppa
	Greenridge Utilities	00HT9423 MDG679423	Winters Run Lake Vista Drive, Joppa
	TC Simons (sand & gravel mine)	95MM9708 MDG499708	Old Mountain Rd, Joppa
	Winters Run Water Treatment Plant	00HT9510 MDG679510	Winters Run Bel Air Road

MDE Permits Listing – Page 5 of 5 Bynum Run Watershed 02130704 (Sept. 2001 data)			
Type / MDE Category	**Facility Name**	**Permit(s) MD/NPDES**	**Receiving Stream / Location**
Groundwater / Municipal	Harford Tech. School	99DP3285	Thomas Run Road, Bel Air
Gen. Industrial Stormwater Permit	Lynch Transportation	97SW0513	Bynum Run Industry Lane, Forest Hill
	Modular Components	97SW0738	Bynum Run Industry Court, Forest Hill
	Bel Air DPW	97SW0016	Bynum Run Churchville Rd, Bel Air
General Permits	Corbin Fuel Company	98OGT4059 MDG344059	Bynum Run East Ellendale St., Bel Air
	Harford Co. DPW	98OGT4197 MDG344197	Bynum Run Fountain Green Road, Bel Air
	Lafarge Quarry	00MM0896 MDG490896	Calvary Road, Churchville

NonPoint Sources

A quantitative estimate of nonpoint source loads (surface water or groundwater) is not available for the Bush River watershed. However, nutrients and sediment are a significant issue in the watershed based on several sources:

– Listing of the river under Section 303(d) of the Clean Water Act

– Modeled nitrogen summary in the *Water Quality Indicators* section in this Watershed Characterization.

– The Maryland Biological Stream Survey identified evidence of nonpoint source problems including erosion in the riparian area, streambank erosion and sedimentation.

Several potential approaches for addressing nonpoint source pollution in the Bush River WRAS were identified in discussions between local representatives and DNR representatives:

– Supporting development of nutrient management plans.

– Promoting the marina pumpout program – especially for summer visitors on the Bush River.

– Identification of septic system problems: existing and potential.

– Supporting development of comprehensive conservation plans for agricultural operations.

– Urban stormwater management

– Lawn maintenance issues

– Potential stream maintenance projects

1. Erosion and Sedimentation

Some Soils in the Bush River basin are prone to erosion. (See the Soil Erodibility Indicator in the Land Use section.)

Based on this limited assessment, the Watershed Restoration Action Strategy may incorporate projects for education and/or incentives for erosion and sediment control.

– Sedimentation Research Findings From Otter Point Creek

The presence of the Otter Point National Estuarine Reserve Research in the Bush River watershed has facilitated understanding of the relation between sediment deposition and local marshes. A brief summary of recently completed research is included below.

Sediment deposition from upstream areas created river delta areas of Otter Point Creek. The physical dynamics of this tidal freshwater delta area have been extensively quantified and modeled.[14] Research on the historic conditions indicate that pre-settlement sedimentation rates were about half of rates from later times when agriculture covered 40 to 50% of the watershed. The long term sediment accumulation rate in Otter Point Creek was as high as 5 cm-yr during the 1840 to 1900 period. This rate is comparable to other delta areas in the Upper Chesapeake Bay.[14] Recent sedimentation cycle study found that marsh areas are growing due to sediment accumulation and incorporation into the marsh matrix.[15]

Study of marsh areas that were previously sewage lagoons at Otter Point Creek indicates that they tend to act as nitrogen sinks.[16] This action is similar to that of other marshes and suggests that these areas act to improve water quality in their vicinity.

2. Shorelines

Wherever land and open water meet, change in the form of erosion or accretion of land is typically the inevitable result of natural processes. Human activity in these areas either tends to inadvertently accentuate these natural processes or purposefully attempts to control movement of water and/or loss of land. Erosion of shorelines can contribute significant amounts of nutrients (mostly phosphorus) and sediment (water column turbidity, habitat loss.)

Historic records show that very large areas of land on the Bush River's western shore appeared since the arrival of the Europeans.[8] This new land includes most of the Edgewood Area of the Aberdeen Proving Ground and the southern shores of Otter Point Creek. It may be inferred that formation of this land was caused by extremely high erosion and sedimentation rates associated with the land clearing and management of the past 300 years.

Countywide shoreline erosion is summarized in the following table. [25]

Harford County Shore Erosion Rate Summary (Miles of Shoreline)				
Total Shoreline	Total Eroding Shoreline	Erosion Rate		
		0 - 2 feet / year	2 - 4 feet / year	> 4 feet / year
140	46(33%)	30	11	5

Maps of historic shoreline change were produced by the Maryland Geological Survey (MGS) in a cooperative effort between DNR and the National Oceanic and Atmospheric Administration (NOAA). Maps produced for Harford County in 1995 included digitized shorelines. Copies of these 1:24000 scale maps are available from the MGS. Updates of these maps should be available by the end of 2002.

Water Supply

In the Bush River Basin, there are eight providers for community water supply systems. The majority use groundwater as their source water but two have surface sources as shown on Map 8 Water Supply. Information for the surface water systems are summarized in the table below.

The community systems served by groundwater in the Bush River Basin are summarized in the table Groundwater Community Water Supply Permits. The groundwater sources serving these systems are mostly unconfined aquifers with the exception of the Potomac Group Aquifer which is tapped by the Harford County Dept. of Public Works. Well head protection areas have been established for the wells operated by Harford County and the City of Aberdeen as shown on the map.[23]

The groundwater sources used for community systems in the Bush River Basin do not employ near-surface groundwater, which is subject to potential local pollution sources. In general, near surface groundwater is credited with carrying nutrients, particularly nitrogen, from land sources to surface waters where nutrient over-enrichment is occurring.

Potential Next Steps. A potential goal or objective for a WRAS could be augmentation of existing programs to protect community water systems by targeting projects or controls in watersheds above surface water intakes.

Surface Water Community Water Supply Permits
Bush River Basin [23]

Permitee Name	Permit ID	Source / Watershed
APG Edgewood	120010	Winters Run / Lower Winters Run
Maryland American Water Works	120003	Winters Run / Atkisson Reservoir

Groundwater Community Water Supply Permits Bush River Basin [15]		
Permitee Name	**Permit Number(s)**	**Source Formation**
Campus Hills Water Works	HA941154	Port Deposit Gneiss
City of Aberdeen	HA736528, HA010406, HA940825, HA028021, HA028020, HA930090, HA734541, HA734540, HA734543, HA734542, HA811140, HA941635, HA732485, HA732483, HA732481	Quaternary System
Fountain Green MHP	HA812346, HA920888	James Run Gneiss
Greenridge Subdivision	HA736693, HA881813, HA881812, HA736829, HA813996, HA813997, HA813998, HA813999, HA881919, HA881918, HA881920, HA881801	Port Deposit Gneiss
Harford County DPW	HA700086, HA710613, HA710165, HA710164, HA660814, HA660813, HA710619	Potomac Group
Lakeside Vista	HA047742, HA813096	James Run Gneiss
Maryland American Water Co.	HA941107	Port Deposit Gneiss

LAND USE

Landscape Indicators

Water quality, particularly in streams and rivers, is affected by the land in the riparian zone and by soils, vegetative cover and the land use throughout the watershed. In an effort to gauge the affects of land use on water quality, and to allow comparison between watersheds, DNR has developed a series of Landscape Indicators. These indicators can be used to portray landscape conditions on a watershed scale that tend to support good water quality or that tend to degrade water quality.

The 1998 *Maryland Clean Water Action Plan* included a unified watershed assessment that used a number of landscape indicators to assess the State's 138 watersheds.[2] Most indicators are relative measures by which a watershed like those in the Bush River Basin can be compared with the other 137 watersheds of similar size that together cover the entire State of Maryland. The following sections identify the findings for the watersheds in the Bush River Basin, with the exception of the population density indicator, which is based on 2000 Census data not available when the *Unified Assessment* was done.

Landscape Indicator (Units)	Bush River	Lower Winters Run	Atkisson Reservoir	Bynum Run	APG	Swan Creek
Impervious Surface (percent)	12.0	18.3	10.2	21.1	31.5	14.2
Population Density (people per acre)	0.94	2.83	1.22	3.18	0.09	0.99
Historic Wetland Loss (acres lost)	9763	3102	1631	3321	258	5940
Unbuffered Streams (percent)	21	34	43	70	26	28
Soil Erodibility (K factor, steepness, etc.)	0.18	0.33	0.31	0.34	0.01	0.33

NOTES: Click on the indicator name to link to its description.

Unshaded indicators in the table mean that average watershed conditions measured by this indicator are better than the Statewide benchmark.

Shaded indicators mean that average watershed conditions measured by this indicator are worse than the Statewide benchmark, i.e. water quality problems are more likely to arise due to the conditions represented by the indicator.

1. Impervious Surface

Based on estimates of imperious cover for each 8-digit watershed in the Bush River Basin averaged across each watershed, the percent of impervious surface cover varies from about 10% to over 30%. These findings for average imperviousness do not compare well with similar watersheds in Maryland.[2]

Roads, parking areas, roofs and other human constructions are collectively called impervious surface. Impervious surface blocks the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surface typically concentrates stormwater runoff, accelerates flow rates and directs stormwater to the nearest stream. Watersheds with small amounts of impervious surface tend to have better water quality in local streams than watersheds with greater amounts of impervious surface. The Maryland Biological Stream Survey has related the percent of impervious surface in a watershed to the health of aquatic resources. For areas with less than 4% impervious cover, streams generally rate "Fair" to "Good" for both fish and instream invertebrates. Beyond about 12% impervious surface, streams generally rate "Poor" to "Fair" for both. Side-effects of impervious surfaces become increasingly significant and negative as the percentage of impervious area increases. Examples of related problems include reduction of groundwater infiltration, increased soil and stream bank erosion, sedimentation, destabilization or loss of aquatic habitat, and "flashy" stream flows (reduced flow between storms and excessive flows associated with storms.)

The impervious surface estimate used for this indicator was generated for the 1998 Maryland Clean Water Action report. Each land use type in the 1994 Maryland State Planning land use data was assigned an estimated imperviousness taken from the TR-55 manual used by the former Soil Conservation Service.

To create a benchmark for comparing impervious area among Maryland watersheds, the percent of impervious area for 8-digit watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. All of the Bush River watersheds exceeded this benchmark.

2. Population Density

According to 2000 Census data, the population density in the watersheds in the Bush River Basin varied from less than one person per acre in the Aberdeen Proving Ground watershed to more than three people per acre in the Bynum Run watershed. The figures in the table differ from those that appeared in the 1998 *Unified Watershed Assessment*. A comparison with other watersheds in the state has not been completed using the 2000 census data.[2]

While population density may be beyond the scope of a WRAS, directing growth is a potential WRAS component. As human population increases, effects of human activity that tend to degrade, displace or eliminate natural habitat also tends to increase. Watersheds with higher populations, assuming other factors are equal, tend to exhibit greater impacts on waterways and habitat. However, growth can be directed in ways to reduce negative impacts.

3. Historical Wetland Loss

The estimated historic loss of wetlands in watersheds in the Bush River Basin varies from a relatively very small 258 acres in the Aberdeen Proving Ground watershed to over 9700 acres in the Bush River watershed. This range of estimated wetland loss in Bush River Basin watersheds is relatively small compared with other similar Maryland watersheds.[2]

This interpretation is based on the assumption that the hydric soils in the watershed were all, at one time, wetlands. Thoughtful selective restoration of historic wetland areas can be an effective WRAS component. In most of Maryland's watersheds, extensive wetland areas have been converted to other uses by draining and filling. This conversion unavoidably reduces or eliminates the natural functions that wetlands provide.

To create a benchmark for comparing impervious area among Maryland watersheds, the historic wetland loss acreage for 8-digit watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. All of the watersheds in the Bush River Basin did not exceed the benchmark because they were not found to be in the highest quartile.

4. Unbuffered Streams

According to data used for the 1998 *Unified Watershed Assessment*, only the Bynum Run watershed in the Bush River Basin had a relatively high percentage of unbuffered streams compared to other similar Maryland watersheds.[2]

DNR recommends that forested buffer 100 feet wide , i.e. natural vegetation 50 feet wide on either side of the stream, is typically necessary to promote high quality aquatic habitat and diverse aquatic populations. Replacement of natural vegetation adjacent to streams can be a valuable and relatively inexpensive WRAS element. In most of Maryland, trees are key to healthy natural streams. They provide numerous essential habitat functions: shade to keep water temperatures down in warm months, leaf litter "food" for aquatic organisms, roots to stabilize stream banks, vegetative cover for wildlife, etc. In general, reduction or loss of riparian trees / stream buffers degrades stream habitat while replacement of trees / natural buffers enhances stream habitat. (For this indicator only "blue line streams" were included. Intermittent streams were not considered.)

This estimate of streams lacking forested buffer was generated for the 1998 Maryland Clean Water Action Plan by using Maryland Department of State Planning GIS data for streams and for 1994 land use.

To create a benchmark for comparing impervious area among Maryland watersheds, the percent of unbuffered streams for 8-digit watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds in the highest quartile (25% of the watersheds) "exceeded" the benchmark. The Bynum Run watershed exceed the benchmark because it was in the highest quartile. The other watersheds in the Bush River basin did not exceed the benchmark because they were not in the highest quartile.

5. Soil Erodibility

For four of the watersheds in the Bush River Basin (Lower Winters Run, Atkisson Reservoir, Bynum Run and Swan Creek), the average soil erodibilty of lands within 1000 feet of streams is greater than 0.30 value/acre which suggests that control of soil erosion is particularly important in these watersheds.[2]

For the Bush River watershed and the Aberdeen Proving Ground watershed, the average soil erodibilty of lands within 1000 feet of streams is 0.18 and 0.01 value/acre which suggests that control of soil erosion is particularly important here.[2]

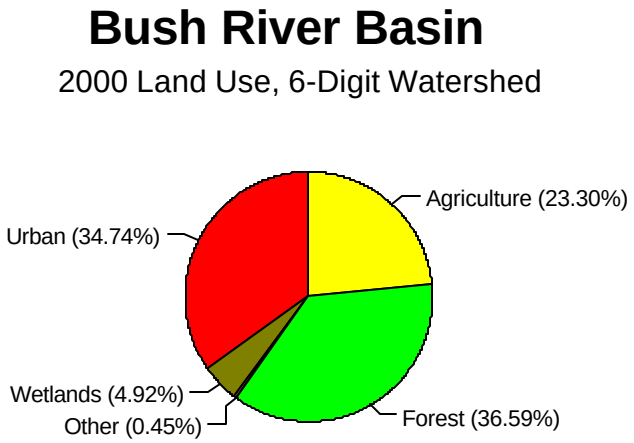
This estimate of soil erodibility was generated through an analysis of GIS data that incorporated the soil erodibility factor (K), slope steepness, land area within 1000 feet of streams and cropland within that 1000 feet buffer based on 1994 Maryland Department of State Planning land use data.

Watersheds with more highly erodible soils are naturally more susceptible to surface erosion, sedimentation, streambank erosion and other problems related to soil movement. These negative effects of soil erodibility on water quality can be minimized through careful management. The soil erodibility indicator accounts for natural soil conditions but not for management of the land. (Existing crop land management was not considered.) The naturally erodible soils in the watershed are addressed by techniques called Best Management Practices (BMPs) to prevent soil loss that are typically in use on local farms. BMPs like no-till, reduced till, cover crops, field strips, and others significantly reduce erosion and sediment movement. These BMPs can be seen in use in many places in the watershed. A WRAS can reasonably promote a reduction in disturbance of erodible soils and/or effective soil conservation practices like planting stream buffers. Because soils can vary significantly within very small areas, a generalized erodibility indicator must be used with caution and supplemented with site-specific evaluation prior to implementing any management action.

To compare Maryland watersheds for this index, the benchmark of 0.275 value/acre was used, i.e. less than 0.275 was considered relatively beneficial for water quality and 0.275 or greater was considered to be a likely factor for water quality problems.

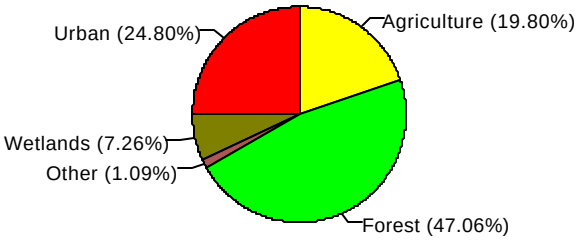
2000 Land Use / Land Cover

The following table and pie chart summarize the Year 2000 land use for the Bush River Basin. Viewing these land uses as potential nonpoint sources of nutrients, agricultural lands are likely to dominate loads to local waterways. Map 9 2000 Land Use / Land Cover shows the distribution of lands in the watershed. Just under 37% of the Bush River Basin is forest. This is up from the estimated 20% forest cover in the same area at the beginning of the 20th Century, which was the peak of deforestation in the area.[14]

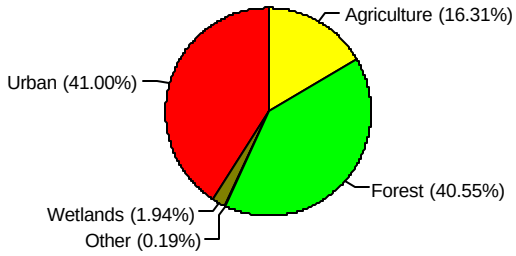


2000 Land Use / Land Cover Bush River Basin in Harford County								
Category		Watershed Area in Acres (Md Dept. of Planning)						
		Bush River	Lower Winters Run	Atkisson Reservoir	Bynum Run	Aberdeen PG	Swan Creek	Total
Agriculture		7,318	1,370	11,488	3,345	219	5,350	29,090
Forest and Brush		17,395	3,406	7,569	3,413	8,426	5,481	45,690
Urban		9,169	3,444	9,913	7,780	7,959	5,117	43,382
Wetlands		2,683	163	28	0	3,176	99	6,149
Other		402	16	23	39	0	84	564
Watershed Total	Land Only	**36,967**	**8,399**	**29,021**	**14,577**	**19,780**	**16,131**	**124,875**
	Land & Water	**45,837**	**8,468**	**29,076**	**14,583**	**21,625**	**16,862**	**136,451**

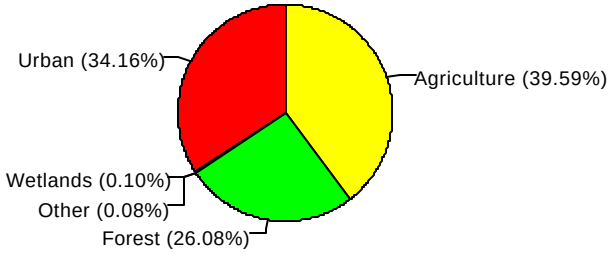
Bush River
8-Digit Watershed



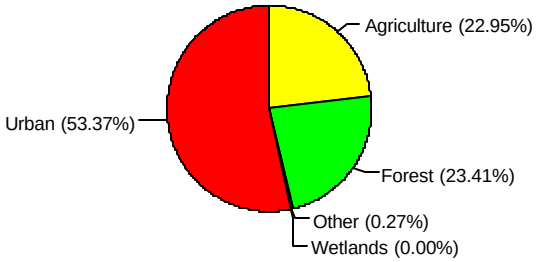
Lower Winters Run
8-Digit Watershed



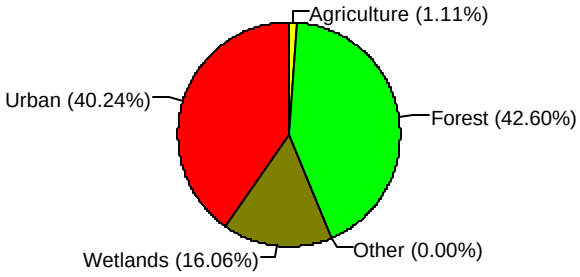
Atkisson Reservoir
8-Digit Watershed



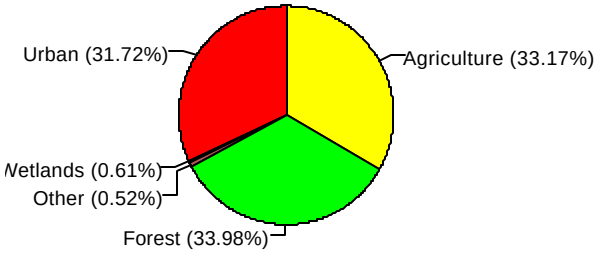
Bynum Run
8-Digit Watershed



Aberdeen PG
8-Digit Watershed



Swan Creek
8-Digit Watershed



Large Forest Blocks / Forest Interior

Large blocks of forest land cover are incorporated into the Green Infrastructure of the landscape. Within large blocks of forest, habitat is available for species that are specialized for conditions with relatively little influence by species from open areas or humans. For example, forest interior dwelling birds require forest interior habitat for their survival and they can not tolerate much human presence. Map 10 Forest Interior shows blocks of contiguous forest that are at least 50 acres in size with at least 10 acres of forest interior (forest edge is at least 300 feet away). This size threshold was chosen to help ensure that the forest interior is large enough to likely provide significant habitat for sensitive forest interior dwelling species.

While blocks of forest interior cover about 22% of the entire Bush River Basin, the amount of large-block forest interior varies significantly among the 8-digit watersheds in the river basin as summarized in the table below:

– About one third of the two watersheds abutting the Chesapeake Bay (Bush River and Aberdeen PG) are covered by large blocks of forest interior.
– Bynum Run watershed has the least forest interior cover relative to other Bush River watersheds.
– The three remaining 8-digit watersheds in the Bush River Basin have similar amounts of forest interior cover (between 14% and 18%).

Forest Interior Habitat Summary Bush River Basin			
Watershed		Forest Interior Acres	Percent of Watershed In Forest Interior
Name	Acres		
Bush River	36,967	11,670	32%
Lower Winters Run	8,399	1,460	17%
Atkisson Reservoir	29,021	3,990	14%
Bynum Run	14,577	480	3%
Aberdeen PG	19,780	6,660	34%
Swan Creek	16,131	2,970	18%
Bush River Basin Total	124,875	27,230	22%
Note: Forest Interior acres in the summary table are rounded to the nearest 10 acres.			

Green Infrastructure

An additional way to interpret land use / land cover information is to identify "Green Infrastructure." In the GIS application developed by Maryland DNR and its partners, Green Infrastructure refers to areas of natural vegetation and habitat that have statewide or regional importance as defined by criteria developed by DNR. The criteria for identifying of lands as Green Infrastructure is limited to considering natural resource attributes currently found on those lands. One example of the criteria is that interior forest and wetlands complexes at least 250 acres in size are considered as part of Green Infrastructure. As a second example, sensitive species habitat that is located within areas of natural vegetation at least 100 acres in size is also counted as Green Infrastructure. Other potential attributes of Green Infrastructure lands, such as ownership or if the current natural conditions are protected in some way, are not criteria for Green Infrastructure but they may be considered independently.

Within the Green Infrastructure network, large blocks of natural areas are called hubs and the existing or potential connections between them are called links or corridors. Together the hubs and corridors form the Green Infrastructure network which can be considered the backbone of the region's natural environment.

Protection of Green Infrastructure lands may be addressed through various existing programs including Rural Legacy, Program Open Space, conservation easements and others. The 2001 Maryland General Assembly approved $35 million for the Green Print program which is targeted primarily to protecting Green Infrastructure areas. This funding category is administered by Program Open Space.

Map 11 Green Infrastructure shows several significant local characteristics of Green Infrastructure:

– Bush River Basin Green Infrastructure hubs tend to be located in lowlands near the Chesapeake Bay in two 8-digit watersheds: Bush River and Aberdeen Proving Ground. These hubs appear to exist because of the protection from development pressure afforded by Federal ownership/management. Another large hub is located in the northern central portion of the Bush River watershed.
– Lower Winters Run and Atkisson Reservoir watersheds have small Green Infrastructure hubs adjacent to major streams.
– Bynum Run watershed has a small portion of a Green Infrastructure hub near its confluence with the Bush River. All other areas of natural vegetation in the watershed did not meet Green Infrastructure criteria (generally too small in size).
– Swan Creek watershed has several Green Infrastructure hubs that are separated by the major highways serving the Baltimore / Philadelphia areas.

Potential Next Steps. Green Infrastructure, Forest Interior Dwelling Species and other views of the landscape could be integrated into various local landuse planning and management scenarios.

Protected Lands

As used in the context of watershed restoration, "protected land" includes any land with some form of long term limitation on conversion to urban / developed land use. This protection may be in various forms: public ownership for natural resource or recreational intent, private ownership where a third party acquired the development rights or otherwise acquired the right to limit use through the purchase of an easement and other mechanisms. The extent of "protection" varies greatly from one circumstance to the next. Therefore, for some protected land, it may be necessary to explore the details of land protection parcel by parcel through the local land records office to determine the true extent of protection.

For purposes of watershed restoration, a knowledge of existing protected lands can provide a starting point in prioritizing potential restoration activities. In some cases, protected lands may provide opportunities for restoration projects because owners of these lands may value natural resource protection or enhancement goals.

The table Protected Lands Summary and Map 12 Protected Land and Smart Growth summarize the status of protected lands in the Bush River basin.

– In the Bush River Basin, Federal land ownership accounts for nearly one third of the land. Federal Land dominates land ownership in two watersheds: Bush River and Aberdeen Proving Ground.
– Non-Federal land protection in the Lower Winters Run watershed is the highest percentage (9%) among watersheds (8-digit) in the Bush River Basin. This relatively high percentage of protection is mostly associated with the Otter Point Creek Park. This property has been designated as a component of the Chesapeake Bay National Estuarine Research Reserve in Maryland. A total of 261 acres of open water and 672 acres of adjoining wetlands and uplands are protected for long-term estuarine research and monitoring and for estuarine education.[4]

Potential Next Steps. Existing protected lands could be assessed as potential contributors or hubs for WRAS implementation. Various types of opportunities could be explored:

– Watershed location should be a factor in considering land protection opportunities.
– Potential sites for implementation projects and/or demonstration projects.
– Opportunities for management enhancement or additional protection.
– Opportunities for expanding protection from currently protected land to adjacent parcels.

Protected Land Summary * Bush River Basin in Harford County							
Category	**Watershed Area Protected in Acres**						
	Bush River	Lower Winters Run	Atkisson Reservoir	Bynum Run	Aberdeen PG	Swan Creek	Total
Conservation Easements	435	362	15	73	0	247	1,132
DNR Land	530	0	0	70	0	0	600
County Parks	132	62	804	30	0	136	1,164
Agricultural Easements	359	312	710	0	0	0	1,381
Agricultural Districts	189	0	361	35	0	0	585
Federal Land	13,390	0	0	0	19,795	719	33,904
Percent of Watershed Protected	4% 41%	9% 9%	5% 7%	1% 1%	0% 100%	2% 7%	3% 31%
	The percent on top excludes agricultural districts and Federal land. The percent shown on the bottom includes all categories listed in the table.						
* Data in this table is from 2000 and/or the late 1990s.							

Smart Growth

Within Maryland's Smart Growth program, there are two targeting programs that should be considered as potential watershed restoration projects are considered. In Rural Legacy Areas, protection of land from future development through purchase of easements (or in fee simple) is promoted. In Priority Funding Areas, State funding for infrastructure may be available to support development and redevelopment. Both are shown in Map 12 Protected Land and Smart Growth:

- Harford County's Rural Legacy Area is located entirely outside of the Bush River Basin, which is mostly in the Deer Creek watershed.

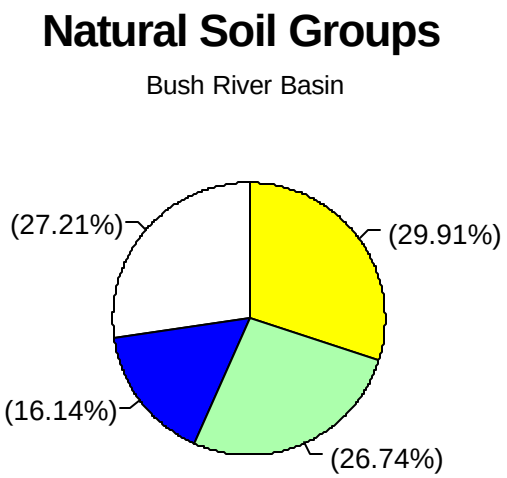
- Priority Funding Areas (PFA) in Harford County are mostly in the Bush River Basin with relatively small areas of PFA located in other County watershed areas. The table below shows the relative PFA area for the Bush River watersheds.

Priority Funding Areas (PFA) Summary Bush River Basin			
Watershed		PFA Acres	Percent of Watershed In PFA
Name	Acres		
Bush River	36,967	12,834	35%
Lower Winters Run	8,399	5,160	64%
Atkisson Reservoir	29,021	5,860	20%
Bynum Run	14,577	12,066	83%
Aberdeen PG	19,780	2,016	10%
Swan Creek	16,131	3,965	25%
Bush River Basin Total	124,875	41,901	34%
Note: Data is from 2000. Acreage in PFAs and protected land acreage are not mutually exclusive. It is common for park land, which is commonly considered to be protected, to be in a PFA to facilitate receiving State funding for park infrastructure. For example, Otter Creek Park is protected from development but it is entirely within a PFA. Therefore, protected land acreage and percentage of a watershed should only be used as an indicator of general direction for development.			

Soils of the Bush River Basin

1. Interpreting Local Conditions with Natural Soil Groups

Soil conditions, like soil type and moisture conditions, greatly affect how land may be used and the potential for vegetation and habitat on the land. Soil conditions are one determining factor for water quality in streams and rivers. Local soil conditions vary greatly from site to site as published information in the Soil Survey for Harford County shows. This complicated information can be effectively summarized using Natural Soil Groups to help identify useful generalizations about groups of soils.



The pie chart shows the distribution of percentages of soils based on broad categories:

-- Yellow - prime agricultural soils

-- Green - all other well drained soils including stony/rocky soils

-- Blue - all poorly drained soils including wetlands and marshes and soils with perched watertables.

-- White - unclassified soils including all of Aberdeen Proving Ground

The Map 13 Soils shows that prime farmland, depicted in yellow or yellow with crosshatching, is widely distributed across the Bush River Basin.

2. Soils and Watershed Planning

Local soil conditions can be a useful element in watershed planning and for targeting restoration projects.

Using Prime Farmland as an example, the scattered location of prime agricultural soils in the Bush River Basin suggests that agricultural preservation efforts need to be targeted to selected areas and prioritized for action to help ensure that protection efforts result in viable agricultural communities. Additionally, prioritization of agricultural cost share funding to these areas could provide additional incentive for local land owners to participate in agricultural preservation programs.

Comparing Map 13 Soils with Map 9 2000 Land Use and Map 11 Green Infrastructure suggests other potential watershed planning approaches. For example, two Green Infrastructure hubs are located north of the tidal Bush River along upper James Run and Grays Run. In these areas, land owners tended to leave poor soils in natural vegetation because the soils were wet or stony. Targeting natural resource protection efforts to areas like this, which offer poor suitability for active use, could benefit both land owners and natural resource protection.

Wetlands

1. Introduction to Wetland Categories [26]

The Bush River Basin has a great diversity of wetland types relative to other Maryland physiographic regions because it includes both Piedmont and Coastal Plain physiographic areas and it has both tidal and nontidal freshwater waterbodies.

Map 14 Wetlands In The Bush River Basin shows the general distribution of wetlands based on the National Wetlands Inventory. The majority of the wetland acreage in the river basin is on Federal land

Brief descriptions of the major wetland categories found in the River Basin are listed below.

Estuarine Wetlands. These systems consist of brackish tidal waters and contiguous wetlands where freshwater runoff from the land receives some saltwater influence. Estuarine wetlands are abundant throughout the Bush River Basin's Coastal Plain covering nearly 5,700 acres. Brackish marshes are found along the shores of Chesapeake Bay and they are the predominant estuarine wetland type in Maryland. Estuarine shrub swamps are common along the Maryland coastal zone. Aquatic beds, comprised mostly of submerged aquatic vegetation, are abundant in shallow water zones of Maryland's estuaries, especially Chesapeake Bay and its tributaries.

Palustrine wetlands. These systems are freshwater wetlands that are not associated with streams or lakes. In the Bush River Basin, this wetland type covers slightly more than 3,700 acres. These wetlands are found on floodplains along the freshwater tidal and nontidal portions of rivers and streams, in upland depressions, and in broad flat areas between otherwise distinct watersheds. Tidal freshwater swamps occur along coastal rivers in areas subject to tidal influence. Scrub-shrub swamps are not abundant but are represented in the Bush River Basin. Emergent wetlands on the Coastal Plain are characterized by a wide range of vegetation, depending on water regime. (Adapted from *Wetlands of Maryland*, Tiner and Burke, 1995.)

Lacustrine wetlands (associated with lakes) and Riverine wetlands (associated with rivers) cover relatively small areas of the Bush River river basin: 54 acres and 21 acres respectively.

2. Wetland Studies In the Bush River Basin

The presence of the Otter Point National Estuarine Reserve Research in the Bush River watershed has facilitated understanding of plant populations in local marshes. During the 1990s, a plant list for Otter Point Creek compiled by William Hilgartner identified 133 species of herbaceous plants and 39 species of woody plants.[17]

3. Tracking Wetlands

Oversight of activities affecting wetlands involves several regulatory jurisdictions. The Maryland Department of the Environment (MDE) is the lead agency for the State and cooperates with DNR, the Army Corps of Engineers and other Federal and local agencies. As part of its responsibility, MDE tracks State permitting and the net gain or loss of wetlands over time. As the Wetlands Regulatory Status table shows, changes tracked in the State regulatory program have amounted to a small net increase in nontidal wetland acreage in the Bush River watershed.

Research findings from Otter Point Creek associated with the Otter Point National Estuarine Reserve Research in the Bush River watershed has facilitated understanding of the changes over time in local marshes. According to research reported in 1998, the mix of wetland types in the upper Otter Point Creek tidal freshwater marshes has changed greatly since early colonial times. In about 1730, nearly the entire marsh area here was subtidal, i.e. the marsh was mostly underwater. By 1990, the same marsh area had changed so that its area was roughly one third subtidal, one third intertidal and one third forested.[14] The change appears to be associated with sediment deposition and incorporation into the marsh.[15]

Tracking Nontidal Wetland Change In The Bush River Basin In Acres 1/1/1991 through 12/31/2001 [20]

Basin Code	Watershed	Permanent Impacts	Permittee Mitigation	Programmatic Gains	Other Gains	Net
02130701	Bush River	-8.01	10.19	0	0.76	2.94
02130702	Lower Winters Run	-3.43	8.47	0	0	5.05
02130703	Atkisson Reservoir	-3.55	9.03	0	0	5.48
02130704	Bynum Run	-8.37	6.15	0	0	-2.22
02130705	Aberdeen Proving Ground	-0.13	0	0	0	-0.13
02130706	Swan Creek	-5.27	7.85	2.20	0	4.78
021307	Bush River Basin	-28.75	41.71	2.20	0.76	15.91

Notes: Only nontidal wetland changes are shown, tidal wetland changes are excluded. Acreage presented for each watershed is not normalized. Regulatory tracking for authorized nontidal wetland losses began in 1991. Comprehensive tracking of voluntary wetland gains began in 1998.

4. Interpreting Wetland Distribution

Wetlands in the Bush River Watershed (02130701) are shown in Map 15 Wetlands On Non-Federal Land: Bush River Watershed. The table below accompanies the map with a summary of wetland categories and acreage. Based on the DNR wetlands data used for the map, forested fresh water wetlands are the largest category of wetlands in this area. The data source used for this interpretation has not been completed for the entire Bush River Basin.

In the context of the Watershed Restoration Action Strategy (WRAS), wetlands serve valuable water quality and habitat functions that may not be provided by other land uses. Therefore, protection and enhancement of existing wetlands, and restoration of past wetland areas, can be a valuable element in the WRAS. (Also see the Wetland Restoration section.)

Wetlands Area Summary for
Map 15 Wetlands On Non-Federal Land:
Bush River Watershed - 02130701 [26]

Wetland Class		Acres
Estuarine, Subtidal	unconsolidated bottom	1
Estuarine, Intertidal	emergent	140
	unconsolidated shore	120
Lacustrine	unconsolidated bottom	8
Palustrine (P)	emergent	100
	forested	416
	scrub shrub	6
	unconsolidated bottom	82
	unconsolidated shore	14
Riverine	unconsolidated shore	1
Totals	DNR Wetlands on Non-Federal Land	888
	National Wetlands Inventory on Non-Federal Land	670
	Non-Federal Land in 02130701	25,626
	All Land in 02130701	36,967

Notes: The DNR wetlands data represented is the highest resolution wetlands data available for the Bush River Watershed (02130701). However, coverage for the Bush River Basin (021307) is incomplete. The National Wetlands Inventory is available for the entire Bush River Basin but it has a lower resolution and, therefore, identifies a smaller wetland acreage for the same geographic area. In comparison, the generalized land use / land cover data presented earlier in this chapter is the lowest resolution data that identifies wetlands and, therefore, identifies even fewer wetlands in the same geographic area.

See the Sensitive Species Section for discussion on Wetlands of Special State Concern.

Floodplains and Low Elevation Areas Subject to Sea Level Rise

Floodplains and associated riparian areas are naturally important areas for habitat and hydrologic functioning of streams. Map 16 Floodplain shows that the most 100-year floodplains in the Bush River Basin are located on Federal land. On non-Federal land, two of the largest 100-year floodplain areas are on lower Winters Run and near the confluence of Bynum Run and James Run. Most floodplain areas are too small to be seen at the basin-wide scale and require subwatershed scale or smaller assessment.

Most areas of the Bush River Basin have sufficient elevation to be unaffected by any potential for sea level rise in the next 50 to 100 years. As a gauge of potential sea level rise risk, a Maryland-wide assessment of land with an elevation of 1.5 meters or less was first published in 1998 and then repackaged in a 2000 State report. According to this report, all the at-risk areas identified in the Bush River Basin are on Federally managed land.[24] Currently, DNR is considering sea level rise as it works to improve prediction of shoreline erosion. New information that may be generated by this effort will be shared with local jurisdictions and other stakeholders as it becomes available.

Potential Next Steps. Protection of people and property has always been the core of floodplain management. Additional objectives for watershed management relative to floodplains may include conservation of habitat, targeting for restoration of wetlands and stream buffers, and prioritization for protecting selected areas from development or inappropriate uses.

Using information gathered in the Stream Corridor Assessment, restoring natural floodplain and wetland function can be one criteria for prioritizing stream restoration projects. Maintaining stable floodplains on a watershed-wide basis can be a factor in determining stormwater management requirements including control of impervious area in a watershed.

LIVING RESOURCES AND HABITAT

Overview

Living resources, including all the animals, plants and other organisms that call the land and waters of the Bush River watershed home, are being affected by human activity. The information summarized here suggests that some of the significant stresses on living resources in the watershed are manipulation of habitat, excessive movement of sediment and excessive availability of nutrients.

The Living Resource information summarized here should be considered a partial representation because numerous areas of potential interest or concern could not be included due to lack of information, time or resources. For example, information on many forms of aquatic life, woodland communities, terrestrial habitats and other factors should be considered as watershed restoration decisions are being made. Therefore, it is recommended that stakeholders in the watershed identify important living resource issues or priorities so that additional effort can be focused where it is most needed. New information should be added or referenced as it becomes available.

Living Resource Indicators

Aquatic organisms are sensitive, in varying degrees, to changes in water quality and aquatic habitat. This association offers two perspectives that are important for watershed restoration. First, improvements for living resources offer potential goals, objectives and opportunities to gauge progress in watershed restoration. Second, the status of selected species can be used as to gauge local conditions for water quality and habitat. This second perspective is the basis for using living resources as an "indicator."

The *Maryland Clean Water Action Plan* published in 1998 listed the following living resource indicators for the Bush River Basin.[2] In the table below, "attain" means watershed conditions are at least as good as the benchmark. "Exceed" means that watershed conditions are not as good as the benchmark. An empty box in the table "–", means that an indicator could not be generated. Several of these indices rely on index rankings generated from a limited number of sampling sites which were then generalized to represent entire watersheds. Considering this limitation on field data, it may be beneficial to conduct additional assessments to provide a more complete understanding of local conditions as part of the WRAS.

Living Resource Indicator	Bush River	Lower Winters Run	Atkisson Reservoir	Bynum Run	APG	Swan Creek
SAV Abundance Index	1.0	--	--	--	--	--
SAV Habitat Requirement Attainment	2.0	--	--	--	--	--
Non-Tidal Benthic Index of Biotic Integrity	--	--	4.4	--	--	--
Non-Tidal Fish Index of Biotic Integrity	--	--	8.50	8.30	--	--
Non-Tidal In-stream Habitat Index	--	--	5.98	6.01	--	–

NOTES: Click on the indicator name to link to its description and interpretation.

Unshaded indicators in the table grid mean that average watershed conditions measured by this indicator are better than the Statewide benchmark.

Shaded indicators mean that average watershed conditions measured by this indicator are worse than the Statewide benchmark, i.e. water quality problems are more likely to arise due to the conditions represented by the indicator.

1. SAV Abundance

For tidal areas of the Bush River watershed, the abundance of submerged aquatic vegetation (SAV) scored "1.0" for the Abundance Indicator which means that SAV covered 10% or less of the potential SAV habitat.

This indicator is designed to allow comparison of watersheds based on actual SAV acreage versus potential SAV acreage. To generate the score for this indicator, two measurements of SAV area were estimated: 1) area covered by SAV in the year 1996 was measured using aerial survey data, and 2) the potential SAV area was measured based on water depth (up to two meters deep), physical characteristics and historic occurrence of SAV.

The benchmark used in the *Unified Watershed Assessment* of the *Clean Water Action Plan* for the SAV Abundance Index was 10%. If less than 10% of the potential SAV area in a watershed was covered by SAV in 1996, then the watershed was listed in the category "needs improvement". If more than 10% of the potential SAV area in a watershed was covered by SAV in 1996, then the watershed was listed in the category "needs preventative action" to protect or enhance SAV abundance. No watershed in the State scored higher than 2, reflecting a maximum observed coverage of 20%.

2. SAV Habitat

For tidal areas of the Bush River watershed, the abundance of submerged aquatic vegetation (SAV) scored "2.0" for the Habitat Index which means that SAV habitat requirements were not met based on 1994-1996 data. This index is designed to allow comparison of watersheds based on several measurements of habitat conditions: water clarity as measured by secchi depth, dissolved inorganic nitrogen where applicable, dissolved inorganic phosphorus, abundance of algae as measured by Chlorophyll *a* and total suspended solids.

The benchmark used in the Unified Watershed Assessment for the SAV Habitat Index was 7. A score less than 7 means that the watershed's habitat conditions were not favorable for SAV and the watershed was listed as being in need of restoration (Category 1). A score of 7 or higher means that 1994 through 1996 data showed that habitat conditions for SAV in a watershed were sufficient and the watershed was listed in the category for "restoration needed".

3. Nontidal Benthic Index of Biotic Integrity (IBI) [21]

The Coastal Plain stream benthic IBI looks at the insects and other invertebrates, like crayfish, living on the bottoms of streams, considering the overall community composition, the number and diversity of species and the presence of sensitive species. To calculate the benthic IBI, for the *Unified Watershed Assessment*, reference conditions were established for minimally-impacted streams. IBI values are relative to conditions in these minimally-impacted streams.

To create a benchmark for this index, local stream scores in the watershed were compared to reference conditions established for minimally impacted streams. An average benthic IBI less than 6.0 for a watershed caused it to be listed as "needs restoration". The Atkisson Reservoir watershed's ranking of less than 6.0 caused it to be listed as "needs restoration" for this index.

4. Nontidal Fish Index of Biotic Integrity (IBI) [21]

As interest in whole ecosystems, and ecosystem health, has grown, Indexes of Biotic Integrity (IBIs) for fishes have been developed for small (first- to third-order) non-tidal streams. Several characteristics of the fish community are measured-- numbers of native species, of benthic species and of tolerant individuals; the percent of tolerant species, of dominant species, and of generalists, omnivores and insectivores; the number of individuals per square meter; biomass in grams per square meter; percent of lithophilic spawners; and percent insectivores. These characteristics are scored and summed to calculate a fish IBI for each sampled stream. Scores for watersheds are reported as means for the sites within each watershed (one most degraded, 10 best condition).

To create a benchmark for this index, local stream scores in the watershed were compared to reference conditions established for minimally impacted streams. An average fish IBI less than 6.0 for a watershed caused it to be listed as "needs restoration". The Atkisson Reservoir and Bynum Run watersheds both had higher index ranks higher than 6.0.

5. Nontidal In-stream Habitat Index [21]

In the Bush River Basin two watersheds had sufficient data for assessment in the nontidal in-stream habitat index. Both the Atkisson Reservoir and Bynum Run watersheds received a score of 6 out of a possible range of scores from 1 (worst) to 10 (best). Of 138 watersheds in Maryland, the 34 (25%) with the lowest nontidal in-stream habitat index received a rank of "exceed" and were designated as Category 1 watersheds in need of restoration. This index allows comparison of streams based fish and benthic habitat as measured by in-stream and riparian conditions. For each stream site that was assessed, visual field observations are used to score the site for substrate type, habitat features, bank conditions, riparian vegetation width, remoteness, aesthetic value and other factors. These scores are then integrated to generate a single rank for each stream site.

Fish and Shellfish

1. Tidal Waters

The Bush River is an important spawning and nursery ground for many fish species.[19]

A survey conducted during the period March 1972 to June 1973 found that the Bush River has considerable spawning by several anadromous, semi-anadromous and local species. These included the commercially important species of striped bass, white perch and herring. It found a wide range of types of fish inhabiting the area. However, two species were clearly dominant in numbers: white perch were said to be ubiquitous and anchovy were found seasonally.[19]

Commercial fisheries harvest information is tracked by Maryland DNR Fisheries Service. This information is available on DNR's Internet site. The Bush River's data is reported for several important commercial species as part of the Upper Chesapeake Bay geographic area (above Worton Point). Reporting for other commercially harvested species is not summarized here because reports are for even larger geographic areas.

– Blue Crabs: Commercial harvest reporting for blue crabs groups Bush River data with the Upper Chesapeake Bay above Worton Point. For this wider area, commercial blue crab harvest for the 1992 to 1999 was significantly higher than in previous years. Since 1992, the annual harvest tended to be greater that 1 million pounds with a significantly higher peak in 1995 of 2,266,000 pounds.

– Oysters: There is no commercial oyster harvest in the Bush River because the regulatory shellfish harvesting restrictions prevent oyster harvest. Even so, the commercial harvest in the entire Upper Chesapeake Bay is a minuscule percentage of the Bay-wide harvest. The very low salinity of the area inhibits oyster habitat and survival.

– Striped Bass: The reported annual harvest for striped bass in 1999 from the Bush River was 5,583 pounds. Prior to 1999, Bush River data was reported as part of the Upper Chesapeake Bay (north of Worton Point). During the late 1990s, the annual harvest for the Upper Bay including the Bush River was typically around 70,000 pounds with one exception in 1998 with a larger harvest of 97,000 pounds.

The Chesapeake Bay's most important striped bass spawning and nursey area is considered to be the Upper Chesapeake Bay based on area size and productivity. The estuarine areas of the Bush River Basin may contribute to the productivity of this area but the relative value of the Bush River is not well understood.

2. Nontidal Areas

General information on fish in nontidal streams is primarily gathered as part of the Maryland Biological Stream Survey. See MBSS Findings for summary information.

The Designated Use of Bynum Run as Use 3 Natural Trout Waters suggests that brook trout where found here. However, DNR Fisheries Service has no records that naturally reproducing trout populations exist anywhere in the Bush River Basin.[28]

3. Fish Consumption

In late 2001, MDE issued revised fish consumption advisories including significant limitations on consumption of some fish species in the Bush River area. The advisory recommends not eating channel catfish and severely limiting meals of white perch caught in the Bush River mainstem. The concern in these fish is contamination from PCBs and/or pesticides. Methylmercury is also a contaminate of concern primarily for some fish species caught in lakes. The table below summarizes advisory for areas in the Bush River Basin. More complete information is available at www.mde.state.md.us/fish_tissue/index.html

In issuing the 2001 advisory, MDE cited changes in the EPA's recommended daily consumption estimates, new sampling data and improved analytical techniques, which led to advisories to limit consumption of 13 species of fish recreationally caught in 14 Maryland waterways. While contaminant levels have not changed, the consumption advisories are especially important for children and women of child-bearing age who are or may become pregnant or are nursing.

Bush River Basin - 2001 Advisory On Fish Consumption
Recommended Maximum Allowable Meals Per Month

Species	Area	General Population 8oz meal	Women 6oz meal	Children 3oz. meal	Contaminant
Channel Catfish	Bush River mainstem	0	0	0	PCBs, Pesticides
White Perch	Bush River mainstem	1	1	0	
Smallmouth & Largemouth Bass, Pickerel, Northern Pike, Walleye	Lakes and other impoundments	4	4	2	Methyl-mercury
	Rivers and streams	no advisory	8	8	
Bluegill	Lakes and other impoundments	8	8	8	

Algae

Based on surveys conducted in 1972-73, the Bush River estuary was found to be rich in phytoplankton throughout most of the spring, summer and early autumn. The survey found nothing peculiar, special or unusual regarding the phytoplankton community. Of the six most common species found, five were diatoms and one was a bluegreen algae. As an indicator of the extent of green algae populations, chlorophyll *a* concentrations only occasionally reached high levels above 50 *u*g/l. The highest chlorophyll *a* concentration reported during the study was 139 *u*g/l.[19]

Maryland Biological Stream Survey [21, 22]

Assessment of biological communities in nontidal streams, like macroinvertebrates, fish and their physical habitat can help with interpretation of aquatic conditions from the perspective of living resources. The Maryland Biological Stream Survey (MBSS) has been conducting these assessments Statewide since 1994. More recently, beginning in the year 2000, MBSS has also facilitated collection of benthic macroinvertebrate information by citizen volunteers in the Stream Waders program.

The MBSS approach involves assessment of each site using a suite of criteria including identification of fish and benthic macroinvertebrate species present. The findings from the criteria are then combined to generate an index for benthic organisms, fish and for physical habitat. The table below shows the scales used to rate findings for the sites shown on the accompanying maps and the table MBSS Findings Summary for the period 1994 through 2000. Additional explanation of the purpose and value of assessing benthic organisms is presented in the text box Why Look At Benthos In Streams. More complete information on the MBSS program and findings for each sampling site is available at http://mddnr.chesapeakebay.net/mbss/search.cfm .

Category	Map 17 Benthic Index Scale of 1 to 5	Map 18 Fish Index Scale of 1 to 5	Map 19 Physical Habitat Index Scale of 0 to 100
Very Poor	1 to 1.99	1 to 1.99	0 to 11.99
Poor	2 to 2.99	2 to 2.99	12 to 41.99
Fair	3 to 3.99	3 to 3.99	42 to 71.99
Good	4 to 5	4 to 5	72 to 100

The surveys reported in the map were conducted by the Maryland Biologcial Stream Survey (MBSS), a program in DNR. Each symbol on the map characterizes a stream segment (about 100 feet) based on the fish/benthic population and habitat conditions. An index of "good" means that the stream segment that was sampled has conditions that are close to those found in a comparable

"reference" stream. Reference streams are found to have the most natural, least impacted stream conditions found in the area for a particular type of stream. Other index findings varying from fair to poor to very poor deviate further and further from reference stream conditions.

Additional monitoring by MBSS is scheduled for the Bush River Basin to assess the in-stream aquatic community and habitat conditions in 2002 (10 sites) and in 2003 (10 sites.)[10] Sampling by citizen volunteers in the MBSS Stream Waders program is anticipated to continue during this time.

Potential Next Steps. MBSS provides site-specific information on nontidal streams that can be considered in the WRAS process to prioritize potential restoration and protection projects. Additionally, for selected streams or project areas, before and after monitoring using MBSS methods can provide a gauge of success for individual projects. MBSS methods can also provide a measure of progress toward water quality improvement goals based on biological indicators.

MBSS Findings Summary for the Bush River Basin

8-Digit Watershed	Sample Year(s)	Number of Sites	Benthic Index	Fish Index	Physical Habitat Index
Bush River	1996	2	Poor: 1 site Very Poor: 1 site	Fair: 2 sites	Good: both sites
Lower Winters Run	1996	2 to 3	Fair: 2 sites Poor: 1 site	Good: 1 site Fair: 1 site	Good: both sites
Atkisson Reservoir	1996	6	Fair: 3 sites Poor: 2 sites	Good: 4 sites Poor: 2 sites	Ranged good to very poor
Bynum Run	1996	5	Fair: 1 site Poor: 3 sites Very Poor: 1 site	Good: 4 sites Poor: 1 site	Good: 4 sites Very Poor: 1 site
Aberdeen PG	1996, 2000	4 to 13	Poor: 4 sites Very Poor: 9 sites	Fair: 1 site Very Poor: 3 sites	Fair: 1 sites Poor: 2 sites Very Poor: 2
Swan Creek	1996, 2000	5 to 13	Good: 5 sites Fair: 4 sites Poor: 3 sites Very Poor: 1 site	Good: 1 site Fair: 3 sties Poor: 1 site	Good: 2 sites Fair: 2 sites Poor: 2 sites Very Poor: 1 site

Why Look at Benthos in Streams?

Benthos are sometimes called "stream bugs" though that name overly simplifies the diverse membership of this group. Unimpaired natural streams may support a great diversity of species ranging from bacteria and algae, to invertebrates like crayfish and insects, to fish, reptiles and mammals. Benthic macro-invertebrates, collectively called benthos, are an important component of a stream's ecosystem. This group includes mayflies, caddisflies, crayfish and similar creatures. that inhabit the stream bottom, its sediments, organic debris and live on plant life (macrophytes) within the stream.

The food web in streams relies significantly on benthos. Benthos are often the most abundant source of food for fish and other small animals. Many benthic macroinvertebrates live on decomposing leaves and other organic materials in the stream. By this activity, these organisms are significant processors of organic materials in the stream. Benthos often provide the primary means that nutrients from organic debris are transformed to other biologically usable forms. These nutrients become available again and are transported downstream where other organisms use them.

Benthos are a valuable tool for stream evaluation. This group of species has been extensively evaluated for use in water quality assessment, in evaluating biological conditions of streams and in gauging influences on streams by surrounding lands. Benthos serve as good indicators of water resource integrity because they are fairly sedentary in nature and their diversity offers numerous ways to interpret conditions. They have different sensitivities to changing conditions. They have a wide range of functions in the stream. They use different life cycle strategies for survival.

Sensitive Species

Sensitive species are most widely known in the form of Federally-listed Endangered or Threatened animals such as the bald eagle. In addition to these charismatic rare animals, both US EPA and Maryland DNR work through their respective Federal and State programs to protect numerous endangered, threatened, or rare species of plants and animals and the habitats that support those species.

For the purposes of watershed restoration, it is valuable to account for known locations of habitat for these species. These places are often indicators, and sometimes important constituents, of the network of natural areas or "green infrastructure" that are the foundation for many essential natural watershed processes. Protecting these species and/or promoting expansion of their habitats can be an effective foundation for a watershed restoration program.

1. Habitat Protection Categories

DNR's Wildlife and Heritage Division uses three designations for areas providing habitat for sensitive species. These designations are described in the text box Maryland's Sensitive Species Protection Areas. As shown in Map 20 Sensitive Species, two of the three sensitive species designations are found in the Bush River Basin. The purpose of these designations is to help protect sensitive species and their habitat through the review of applications for State permits or approvals, and review of projects that involve State funds. For the types of projects potentially described above, DNR makes recommendations and/or requirements to protect sensitive species and their habitat.

These categories do not place requirements on any activities that do not require a permit/approval or do not involve State funds. However, there are State and Federal restrictions that address "takings" of protected species that apply more broadly. In addition, many counties have incorporated safeguards for these areas into their project and permit review processes. In all instances, property owners are encouraged to seek advice on protecting the sensitive species / habitat within their ownership. More details and guidance can be requested from DNR Natural Heritage Division staff.

2. Wetlands of Special State Concern

The Wetlands of Special State Concern (WSSC) in the Bush River Basin are shown in Map 20 Sensitive Species though most are difficult to see at the scale of the map. The largest groupings of the WSSCs are listed in the summary table below.

Wetlands of Special State Concern – Areas of Concentration In The Bush River Basin			
Watershed		**Stream Vicinity**	**Community Vicinity**
Name	**Acres**		
Bush River Watershed 02130701	28	Otter Point Creek	Flying Point Road / Willoughby Woods area
		North of Sod Run	South of Perryman Road, "Perryman Woods" area
		Church Creek	North of Rt 40, "Church Creek Pond"
Atkisson Reservoir 02130703	37	Atkisson Reservoir	Harford Glen Center and Aberdeen PG property
Swan Creek 02130706	44	Swan and Gasheys Creeks, Chesapeake Bay shore area	Oakington Road, Swan Harbor Farm Park
Bush River Basin 021307	109		

3. Maryland Darter

In the Swan Creek watershed (02130706), Gashey's Run was declared critical habitat for the Federally endangered Maryland darter by the US Fish and Wildlife Service in 1984. This designation, in part, means that the US Fish and Wildlife Service reviews activities that meet two conditions 1) a federal permit, license and/or funding in involved, and; 2) there is a potential to impact the species or its habitat.[26]

Sensitive Species Protection Areas in the Bush River Basin

Sensitive Species Project Review Area (SSPRA)

At least 26 SSPRAs are identified in the Bush River Basin. Each SSPRA contains one or more sensitive species habitats. However, the entire SSPRA is not considered sensitive habitat. The SSPRA is an envelope identified for review purposes to help ensure that applications for permit or approval in or near sensitive areas receive adequate attention and safeguards for the sensitive species / habitat they contain. Also see Map 20 Sensitive Species.

Natural Heritage Area (NHA)

No NHAs are located in the Bush River basin (Md 6-digit wateshed). NHAs are rare ecological communities that encompass sensitive species habitat. They are designated in State regulation COMAR 08.03.08.10. For any proposed project that requires a State permit or approval that may affect an NHA, recommendations and/or requirements are placed in the permit or approval that are specifically aimed at protecting the NHA. To help ensure that proposed projects that may affect an NHA are adequately reviewed, an SSPRA is always designated to encompass each NHA and the area surrounding it.

Wetlands of Special State Concern (WSSC)

There are three concentrations of WSSCs designated in the WRAS project area and several are designated elsewhere in the Bush River Basin. These wetlands are associated with one or more sensitive species habitats that are in or near the wetland. For any proposed project that requires a wetland permit, these selected wetlands have additional regulatory requirements beyond the permitting requirements that apply to wetlands generally. To help ensure that proposed projects that may affect a WSSC are adequately reviewed, an SSPRA is always designated to encompass each WSSC and the area surrounding it. For a listing of designated sites see COMAR 26.23.06.01 at www.dsd.state.md.us

Submerged Aquatic Vegetation

The well-defined link between water quality and submerged aquatic vegetation (SAV) distribution/abundance makes SAV communities good barometers of the health of estuarine ecosystems. In addition to its value as a water quality indicator, SAV is also a critical nursery habitat for many estuarine species. For example, blue crab "post-larvae" are up to 30 times more abundant in SAV beds than adjacent unvegetated areas. Additionally, several species of waterfowl depend on SAV for food when they over-winter in the Chesapeake region.

Map 21 Submerged Aquatic Vegetation shows that during the 1980s and 1990s distribution of SAV in the Bush River basin is generally very sparse. Within the WRAS project area, all the SAV areas that were large enough to identify using aerial photography were located adjacent to Federal land. Elsewhere in the Bush River Basin, the largest concentration of SAV has been near Swan Creek. Experience obtained through years of monitoring SAV demonstrates that acreage in the Bush River fluctuates from year to year. For example, SAV acreage in Bush River during the year 2000 was at least 17% and 12 acres greater than acreage in 1999.[29]

The map also shows that potential SAV habitat area based on a water depth of two meters or less. This shallow depth covers extensive areas of the Bush River and the perimeter of the Bush River Basin adjacent to the Chesapeake Bay.

It is believed that the limitations exhibited by historic SAV distribution compared to potential habitat relate in part to excessive nutrient and suspended sediment loads in the Bush River and the Upper Chesapeake Bay. The nutrient loads appear to be driving algae growth that competes with SAV for sunlight. Additionally, suspended sediment also blocks the sunlight which reduces the light that reaches SAV leaves.

Potential Next Steps. Beginning in early 2002, Harford County and numerous Federal and State agencies began cooperating to pool their information on SAV and to generate a consensus on SAV management for the Bush River. The findings and results of this effort can be integrated into the local watershed management strategy.

The Anita C. Leight Estuary Center and Chesapeake Bay National Estuarine Research Reserve (CBNERR) will begin a long term research and restoration project to restore native SAV species to Otter Point Creek and surrounding waters. The staff are using innovative "SAV planting grids" and will be using multiple species of SAV to determine the most suitable species, or combination of species, for restoration to the site.

Also see Related Projects.

RESTORATION TARGETING TOOLS

2002 Stream Corridor Assessment

Using the Stream Corridor Assessment Methodology (SCAM) developed and applied by the DNR Watershed Restoration Division, valuable information can be compiled to assist in targeting restoration activities. In partnership with Harford County, DNR is conducting a Stream Corridor Assessment on Church Creek in the Bush River watershed in 2002. Trained teams from the Maryland Conservation Corps will walk along streams to identify and document potential problems and restoration opportunities such as the items listed below: DNR will provide a report for County use.

Stream Corridor Assessment Data Collection Categories	
Pipe Outfalls	Fish Blockages
Pond Sites	Exposed Pipe
Tree Blockages	Unusual Conditions
Inadequate Buffers	Trash Dumping
Erosion	In or Near Stream Construction

Potential Next Steps. Harford County has demonstrated success in using Stream Corridor Assessments to identify restoration projects. For the WRAS, this information can be used as a foundation to prioritize/target geographic areas for restoration and/or types of projects for implementation in a watershed-based management strategy.

Recent Stream Corridor Assessments

Harford has completed several Stream Corridor Assessments in the Bush River Basin including Bynum Run (1995-1996), Swan Creek (Spring 1994 - Spring 1995) and Winters Run (1998). Each report identifies each site where problems are identified and ranks its severity relative to other sites. Each report also singles out specific sites that are considered particularly severe. As an example of this work, the table below summarizes the findings from the Bynum Run effort.[7]

Bynum Run Stream Corridor Assessment Findings Matrix for Winter 1995-1996							
Potential Problems Identified	**Count**	**Length Est. feet / miles**	**Severity Frequency**				
			1	**2**	**3**	**4**	**5**
Erosion (stream banks)	214	86,818 / 16.4	23	50	82	49	11
Pipe Outfalls	172		24	8	33	43	64
Fish Blockages	143		45	26	35	22	15
Inadequate Buffers, Unshaded Streams	118	62,954 / 11.9	14	22	47	22	13
Channel Alternation	71	12,554 / 2.4	15	3	20	19	14
Exposed Pipe	24		1	5	9	2	7
Unusual Conditions	23		6	5	6	1	5
Trash Dumping	10		2	1	4	2	1
Livestock	9	3,100 / 0.6	2	--	2	--	5
TOTAL	784		132	120	238	160	135

2002 Synopic Survey and Benthic Community Assessment

Based on 2002 sampling in the Bush River watershed, DNR staff will report on water quality in nontidal streams to supplement knowledge of local conditions. Based on parameters listed below, the survey findings will help identify problem areas and relative conditions among local streams. It will also help rank subwatersheds by their nutrient load contributions to tidal areas of the Bush River.

For the same 2002 sampling sites, DNR staff will also report on benthic organism populations in nontidal streams as a gauge of water quality and habitat conditions. DNR's report of 2002 findings will include assessment of water quality, benthic organism populations and the potential relationships that may be drawn from the 2002 data.

Synopic Survey Data Collection Parameters	
Dissolved Oxygen	Nutrients (nitrogen and phosphorus)
pH	Conductivity

Aricultural Conservation Programs

Harford County has a high level of participation in agricultural conservation programs. Farmers in the county willingly implement management systems that address nutrient runoff and infiltration, erosion and sediment control, and animal waste utilization. The Harford Soil Conservation District (HSCD) works with farmers and landowners in the development of Soil Conservation and Water Quality plans that recommend best management practices that will prevent nutrient and sediment impact on surface and ground water. Some of the conservation practices installed were grassed waterways, riparian herbaceous and riparian forested buffers, conservation cover, cover crops, shallow water wildlife areas and grade stabilization structures. The Maryland Agricultural Cost-Share program (MACS), the Conservation Reserve Program (CRP and CREP) and the Environmental Quality Incentive Program (EQIP) are some of the state and federal programs promoted and administered by the Harford SCD and NRCS. [28]

Farmers in the watershed who are already using good management practices that benefit water quality could provide examples to promote adoption of similar practices by other farmers.

Potential Next Steps. Encouraging implementation of BMPs, nutrient management, participation in conservation programs and other agricultural approaches to protecting water quality are important elements in local water management strategy that can be augmented through the WRAS process.

Marina Programs

Discharges of sewage from boats are a concern for water quality because they contribute nutrients, biochemical oxygen demand, pathogens, etc. These discharges are preventable if a sufficient number of pumpout facilities are locally available and boat operators take advantage of these services.

Three of the five marinas in the Bush River offer pumpout facilities as shown in Map 22 Marinas. None of these marinas is currently participating in Maryland's Clean Marina Program.

The Clean Marinas Program is a way for marina owners to gain certification and public recognition for voluntarily undertaking a number of actions related to marina design, operation, and maintenance intended to properly manage all kinds of marine products and activities, and to reduce and properly manage waste. Information is available at DNR's website, www.dnr.state.md.us/boating.

DNR also funds installation and maintenance of marine pumpout facilities, including those at certified Clean Marinas. Information may be obtained from the Waterway and Greenways Division at DNR.

One potential element of a Watershed Restoration Action Strategy (WRAS) is to encourage and/or support adding marina pumpout facilities serving the local area and increasing participation in the Clean Marina Program.

Fish Blockage Removal

Many fish species need to move from one stream segment to the next in order to maintain healthy resilient populations. This is particularly true for anadromous fish species because they spawn and hatch from eggs in free flowing streams but live most of their lives in estuarine or ocean waters. Blockages in streams can inhibit or prevent many fish species from moving up stream to otherwise viable habitat.

To help prioritize stream blockages for mitigation or removal, the DNR Fish Passage Program maintains a database of significant blockages to fish movement. A summary of blockages listed in the database for the Bush River Basin appears in the Fish Blockages / Removal Opportunities Table and Map 23 Fish Blockages. The listings in this database should be considered as supporting information for Stream Corridor Assessments that have been completed or are planned. Based on experience in other watersheds, it is likely that an assessment would identify additional potential fish blockage problems.

Of the more than twenty fish blockages listed in the database, one on Lower Winters Run known as Van Bibber Dam was mitigated in 1990. Correction of this blockage reconnected a large segment of Lower Winters Run to the Chesapeake Bay.

Potential Next Steps. In general, mitigation or removal of a blockage to fish movement is recommended if the change would open a significant stream segment containing high quality habitat with existing or potential return of significant fish populations. DNR Fisheries Service can provide technical advice and potentially funding for mitigation projects. Some blockages to fish movement may be structural components of lakes, farm ponds or drainage ditches. If a blockage is found in any of these categories, circumstances like requirements for public recreation needs, drainage control function, land owner needs and other factors are considered in determining the potential for a restoration project.

Fish Blockages / Removal Opportunities in the Bush River Basin — Page 1 of 2				
Watershed (8-Digit)	**Station**	**Blockage Corrected**	**Stream**	**Name / Location**
Bush River 02130701	BU010		Gray's Run	Carsins Run Road
	BU011		James Run	0.25 miles above I-95
	BU012		James	James Run Road
	BU013		Unnamed Tributary	Gulf Road
	BU014		Unnamed Tributary	0.3 miles below Rt. 159
Lower Winters Run 02130702	BU016	yes	Otter Point Creek	0.1 miles above Edgewood
	BU017		Lower Winters Run	50ft below Atkisson Dam
	BU018		Lower Winters Run	0.2 miles above Singer Road
Atkisson Res. 02130703	BU019		Winters Run	25 yards above Rt 1
Bynum Run 02130704	BU001		Bynum Run	1 mile below Wheel Road
	BU002		Bynum Run	1 mile above Wheel Road
	BU003		Bynum Run	0.8 miles above Wheel Road
	BU004		Bynum Run	0.5 miles below St. Andrews Rd.
	BU005		Bynum Run	0.1 mile below St. Andrews Rd.
	BU006		Bynum Run	0.6 miles below Rt. 1
	BU007		Bynum Run	0.7 miles below Rt 23
	BU008		Bynum Run	Rt 23
Aberdeen PG 02130705	no blockages listed in database			
Note: Fish Blockage Database records may not include findings from Stream Corridor Assessments.				

Fish Blockages / Removal Opportunities in the Bush River Basin — Page 2 of 2				
Watershed (8-Digit)	**Station**	**Blockage Corrected**	**Stream**	**Name / Location**
Swan Creek 02130706	CW010		Gashey's Creek	0.2 mile below Chapel Road
	CW011		Gashey's Creek	Chapel Road
	CW030		Swan Creek	0.1 mile above Rt. 40
	CW031		Swan Creek	100 ft. above Oak St.
	CW032		Swan Creek	130 yards above Oak Street
	CW063		Unnamed Trib to Gashey's Creek	0.33 mile below Chapel Road
	CW064		Unnamed Trib to Gashey's Creek	Chapel Road
Note: Fish Blockage Database records may not include findings from Stream Corridor Assessments.				

Stream Buffer Restoration

1. Benefits and General Recommendations

Natural vegetation in stream riparian zones act as stream buffers that can provide numerous valuable environmental benefits:

– Reducing surface runoff
– Preventing erosion and sediment movement
– Using nutrients for vegetative growth and moderating nutrient entry into the stream
– Moderating temperature, particularly reducing warm season water temperature
– Providing organic material (decomposing leaves) that are the foundation of natural food webs in stream systems
– Providing overhead and in-stream cover and habitat
– Promoting high quality aquatic habitat and diverse populations of aquatic species.

To realize these environmental benefits, DNR generally recommends that forested stream buffers be at least 100 feet wide , i.e. natural vegetation 50 feet wide on either side of the stream. Therefore, DNR is promoting this type of stream buffer for local jurisdictions and land owners who are willing to go beyond the minimum buffer standards. The DNR Watershed Restoration Division and other programs like CREP are available to assist land owners who volunteer to explore these opportunities.

2. Using GIS

Identifying the areas that need buffer restoration and prioritizing them for action can be a time-consuming expensive project. Fortunately, use of a computerized Geographic Information System (GIS) to manipulate remote sensing data can help save limited time and funds. To assist in this technical endeavor, DNR Watershed Management and Analysis Division is offering assistance, including GIS work, to help target restoration of naturally vegetated stream buffers, wetlands and other watershed management projects that may be identified locally. With these tools, information generated by a Stream Corridor Assessment and additional on-the-ground verification or "ground truthing," local government may more efficiently and confidently consider stream buffer restoration as part of a local Watershed Restoration Action Strategy.

Several scenarios are presented here to help consider potential areas for stream buffer and wetland restoration. These scenarios can be used alone or in combination as models for targeting potential restoration sites for field verification. These maps are intended to demonstrate a methodology that can be used to locate sites having a high probability of optimizing certain ecological benefits of stream buffers. The resolution of the data used to generate these maps is not sufficient for an accurate site assessment, but can be used to identify potential candidate sites for more detailed investigation. The streams presented in the maps are perennial (blue line) streams as generally shown on US Geological Survey Quadrangle Maps. Intermittent streams were not considered in the stream buffer scenario maps.

3. Headwater Stream Buffers

Headwater streams are also called first order streams. These streams, unlike other streams (Second Order, etc.), intercept all of the surface runoff within the watersheds that they drain. In addition, for many watersheds, first order streams drain the majority of the land within the entire watershed. Therefore, stream buffers restored along headwater streams (First Order) tend to have greater potential to intercept nutrients and sediments than stream buffers placed elsewhere. In targeting stream buffer restoration projects, giving higher priority to headwater streams is one approach to optimizing nutrient and sediment retention.

Restoring headwater stream buffers can also provide habitat benefits that can extend downstream of the project area. Forested headwater streams provide important organic material, like decomposing leaves, that "feed" the stream's food web. They also introduce woody debris which enhances in-stream physical habitat. The potential for riparian forest buffers to significantly influence stream temperature is greatest in headwater regions. These factors, in addition to positive water quality effects, are key to improving aquatic habitat.

4. Land Use and Stream Buffers

One factor that affects the ability of stream buffers to intercept nonpoint source pollutants is adjacent land use. Nutrient and sediment loads from different land uses can vary significantly.

The loading rates shown in the table here were calculated for the Lower Potomac River Tributary Basin from the model of the Chesapeake Bay Watershed Model.

Annual Nonpoint Source Pollution Load Rates By Land Use Chesapeake Bay Watershed Model (2000)

Land Use	Nitrogen (lbs/ac)	Phosphorus (lbs/ac)	Sediment (tons/ac)
Crop land	17.11	1.21	0.74
Urban	7.5	0.7	0.09
Pasture	8.40	1.15	0.30
Forest	1.42	0.00	0.03

Restoration of stream buffers is a valuable agricultural Best Management Practice (BMP). By identifying land uses in riparian areas with inadequate stream buffers, like crop land adjacent to streams, the potential to reduce nutrient and sediment loads can be improved. To assist in finding areas with crop land adjacent to streams, the same land use data shown in Map 9 2000 Land Use / Land Cover can be filtered using GIS. The new scenario shown in Map 24 Stream Buffer Land Use Scenario focuses on the land use within 50 feet of a stream. This view, supplemented with the land use pollution loading rates, suggests potential buffer restoration opportunities that could minimize nutrient and sediment loads. (Note: DNR is encouraging stream buffers 150 feet wide on each side of the stream, which is significantly greater than minimum buffer requirement, to enhance nutrient and habitat benefits beyond minimum buffer requirements.)

5. Nutrient Uptake from Hydric Soils in Stream Buffers

In general, the nutrient nitrogen moves from the land into streams in surface water runoff and in groundwater. In watersheds like the Bush River Basin, a significant percentage of nitrogen enters streams in groundwater. Stream buffers can be used to capture nitrogen moving in groundwater if buffer restoration projects have several key attributes:

– Plant with roots deep enough to intercept groundwater as it moves toward the stream
– Plants with high nitrogen uptake capability, and
– Targeting buffer restoration projects to maximize groundwater interception by buffer plants.

Hydric soils in stream riparian areas can be used as one factor to help select stream buffer restoration sites. Siting buffer restoration on hydric soils would offer several benefits:

– Plant roots are more likely to be in contact with groundwater for longer periods of time
– Hydric soils tend to be marginal for many agricultural and urban land uses
– Natural vegetation in wet areas often offers greater potential for habitat.

Map 25 Stream Buffer Hydric Soils on Open Land Scenario identifies lands adjacent to streams that are composed of hydric soil and also have insufficient stream buffers in the central part of the Bush River Basin. The map suggests that several areas north of Bel Air have unbuffered streams on hydric soils. This type of area could offer opportunities to restore stream buffers and intercept nitrogen in near-surface groundwater before it reached the nearby stream.

To generate the map, hydric soils (Natural Soils Group of Maryland, MDP) were grouped into two classes and rated in terms of their potential to maximize groundwater/root zone interaction: poorly drained hydric soils (high nutrient retention efficiency), and moderately well drained hydric soils (moderately high nutrient retention efficiency). An important next step in using this information is verification of current field conditions. Care must be taken during field validation to evaluate any hydrologic modification of these soils, such as ditching or draining activities, which would serve to decrease potential benefits.

6. Optimizing Water Quality Benefits by Combining Priorities

Strategic targeting of stream buffer restoration projects may promote many different potential benefits. To maximize multiple benefits, site selection and project design need to incorporate numerous factors. For example, finding a site with a mix of attributes like those in the following list could result in the greatest control of nonpoint source pollution and enhancement to living resources:

– land owner willingness / incentives
– marginal land use in the riparian zone
– headwater stream
– hydric soils
– selecting appropriate woody/grass species
– adjacent to existing wetlands / habitat

Additionally, selecting restoration projects that are likely to produce measurable success is an important consideration in prioritizing projects for implementation. In the early stages of a watershed restoration program, measurable water quality improvement can be one of the strongest ways to demonstrate project success.

In general, targeting restoration projects to one or a few selected tributaries or small watersheds will tend to offer the greatest probability of producing measurable water quality improvement. By selecting small areas like a small first order stream for restoration, there is greater likelihood that water quality problems arise locally and that they can be corrected by limited investment in carefully selected local restoration projects.

In the Bush River Basin, available water quality data reinforces the premise that targeting restoration projects to locally generated problems is an important consideration. Because significant inputs to water quality in tidal portions of the Bush River arise from multiple tributary streams and tidal exchange with the Chesapeake Bay, it be will difficult for local projects to demonstrate water quality improvements in tidal waters.

However, if watershed restoration projects are targeted to selected tributary streams, improvement in in-stream water quality are more likely to be measurable in terms of water quality parameters, benthos populations or other parameters. Water quality improvements achieved in the tributary will also inevitably contribute to improving the river mainstem. However, improvement in the mainstem of the river may not be measurable if the magnitude of the problem is as great as the data suggest.

Wetland Restoration

Wetlands serve important environmental functions such as providing habitat and nursery areas for many organisms, facilitating nutrient uptake and recycling, and providing erosion control and sediment trapping. However, most watersheds in Maryland have significantly fewer wetland acres today than in the past. This loss due to draining, dredging or filling has led to habitat loss and negative water quality impacts in streams and in the Chesapeake Bay. Reversing this historic trend is an important goal of wetland restoration. One approach to identifying candidate wetland restoration sites involves identifying "historic" wetland areas based on the presence of hydric soils. This process can be accelerated by using GIS to manipulate soils information with other data like land use. The GIS products can then assist in initiating the candidate site search process, targeting site investigations and helping to identify land owners. To promote wetland restoration, DNR Watershed Management and Analysis Division has developed GIS capability for these purposes.

For the Bush River and Bynum Run 8-digit watersheds, GIS was used to map and prioritize areas of hydric soil for potential wetland restoration. The steps and priorities used to generate the map are listed below:

– Data used: Hydric soils (Natural Soil Groups), existing wetlands (National Wetlands Inventory), land use (DOP 1997).
– Identify candidate hydric soil areas based on land use. Hydric soils on open land (mostly agricultural fields or bare ground) are retained while those underlying natural vegetation and developed lands are excluded.
– Explore hydric soils based on land ownership and proximity to existing wetlands or streams.

Two of many possible scenarios for finding potential wetland restoration sites are presented on the accompanying maps:

– Map 26 Wetland Restoration Opportunities shows that there are numerous concentrations of hydric soils that are near existing wetlands. These areas could be candidates for wetland restoration. The areas identified on the map along Lower Winters Run near the existing protected land at Otter Point could offer both restoration and natural resource protection opportunities within an existing management program.

– In comparing Map 26 with Map 25 Stream Buffer Hydric Soils on Open Land, several areas appear in both the stream buffer and the wetland restoration scenarios. For example, the headwaters area of Broad Run, James Run and Grays Run may be candidates for restoration projects that could meet multiple natural resource and water quality protection objectives.

The potential wetland restoration sites suggested in these scenarios can be filtered further by using more accurate wetlands and soil information, considering landownership and other factors. Additional steps would be beneficial in applying this information such as considering additional criteria like habitat enhancement opportunities, sensitive species protection, targeting specific streams or subwatersheds for intensive restoration, and using Conservation Reserve Enhancement Program (CREP) information.

Additional wetland restoration opportunities may be identified on non-agricultural lands. For example, residential properties, particularly low density areas, may also provide viable project sites that do not appear on the scenarios presented above.

PROJECTS RELATED TO THE WRAS PROCESS

Overview

There are numerous projects and programs that have the potential to contribute to successful development and implementation of a Watershed Restoration Action Strategy (WRAS). The listing included here suggests opportunities for cooperation and coordination that can improve the likelihood of success for the WRAS. This listing is not all-inclusive. It is recommended that this list be augmented as new information becomes available and that follow-up should continue to promote the WRAS process with these and other projects and programs.

319(h)-Funded Projects

The Federal funding source generally known as "319" is not currently funding projects in the Bush River Basin.

Other Projects

This section summarizes projects that have the potential to contribute to development and implementation of the Watershed Restoration Action Strategy that have not been addressed elsewhere in the watershed characterization.

1. 2002 SAV Experiment In Otter Point Creek

Three species of submerged aquatic vegetation (SAV) have been transplanted from grow out stations at the Anita C. Leight Estuary Center to prescribed areas of Otter Point Creek to test habitat suitability. This project was conducted by Chesapeake Bay National Estuarine Research Reserve (CBNERR) staff along with volunteers as part of the Reserves' research function.

2. Anita C. Leight Estuary Center 2002 Access Improvement

The Chesapeake Bay National Estuarine Research Reserve partnered with DNR Program Open Space, Harford County Parks and Recreation and the Harford Land Trust to purchase property near the Anita C. Leight Park which is in the Otter Point Component of the Reserve. Subject to necessary approvals and permits, improvements will include replacement an existing unsafe pier with an ADA accessible pier, addition of an ADA path from the parking area to the pier, and a parking lot upgrade to create a safe ADA parking. The new area will be used for public canoe and pontoon boat programs and as a monitoring site.

POTENTIAL BENCHMARKS FOR WRAS GOAL SETTING

Several programs designed to manage water quality and/or living resources have existing or proposed goals that are relevant to setting goals for the Bush River Watershed Restoration Action Strategy (WRAS). The goals from these other programs tend to overlap and run parallel to potential interests for developing WRAS goals. Therefore, to assist in WRAS development, selected goals from other programs are included here as points of reference.

Coastal Zone Management

– The Watershed Restoration Action Strategy (WRAS) Initiative is a component of the Cumulative and Secondary Impacts section of the *Maryland Coastal Zone Management Program Section 309 Strategy (2000-2005)*. Watershed strategies are defined as comprehensive plans that will identify areas of concern, monitoring strategies, gaps in information, mitigation options, and restoration and protection opportunities.

– WRAS projects funded under Coastal Zone Management must be in Maryland's Coastal Zone and must include a local program change as part of the effort. This could include incorporation into the County Comprehensive Plan, adoption of local implementing tools like zoning ordinances and environmental codes, modification of sensitive areas elements or alterations to Smart Growth Priority Funding Areas.

Chesapeake 2000 Agreement

The Chesapeake 2000 Agreement (C2K) includes several significant commitments pertaining to local watershed management planning and implementation. The goal in the C2K Agreement that is directly related to the development of watershed management plans and action strategies is "By 2010, work with local governments, community watershed groups and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the Bay watershed covered by this Agreement. These plans would address the protection, conservation and restoration of stream corridors, riparian buffers and wetlands for the purposes of improving habitat and water quality, with the collateral benefits for optimizing flow and water supply."

Four common elements of watershed management planning were adopted by the Chesapeake Bay Program member jurisdictions to be applied Bay-wide. Those elements support the WRAS components which were also identified as common Bay-wide criteria for watershed management planning. The four approved C2K Agreement watershed planning elements are as follows:

1. Does the plan "address the protection, conservation and restoration of stream corridors, riparian forest buffers and wetlands?" Each watershed management plan needs to be based on an assessment of natural resources within the watershed. At a minimum, the assessment will evaluate the condition of stream corridors, riparian buffers and wetlands within the watershed.

2. Does the plan reflect the goals and objectives of "improving habitat and water quality?" The plan should reflect the issues that the stakeholders feel are important, and, at a minimum, exhibit a

benefit to habitat and water quality within the watershed.
The goals should be based on priority issues identified by the watershed assessment.

3. Chesapeake 2000 Watershed Commitments Criteria #3
Does the plan identify implementation mechanisms?
Capacity to implement the plan will be demonstrated by identifying:
- What are the specific management actions?
- What are the resources necessary for implementation?
- Who will implement the plan?
- And when will the actions will be implemented?

The implementation mechanisms should also incorporate a periodic re-evaluation to ensure the plan is "living" and flexible to the changes in the watershed.

4. Does the plan have demonstrated local support? Every effort should be made to demonstrate a diversity of local support. At a minimum, local governments, community groups and watershed organizations should be encouraged to participate in developing and implementing the watershed management plan.

Goals from the *Clean Water Action Plan* [2]:

– Clean Water Goals - Maryland watersheds should meet water quality standards, including numerical criteria as well as narrative standards and designated uses.

– Watersheds should achieve healthy conditions as indicated by natural resource indicators related to the condition of the water itself (e.g. water chemistry), aquatic living resources and physical habitat, as well as landscape factors (e.g. buffered streams and wetland restoration).

Water Quality Improvement Act of 1998

- The most significant feature is requiring nutrient management plans for virtually all Maryland farms. The requirement is being phased in over a several year period.
- Nitrogen-based plan implementation will be required on all farms beginning December 31, 2001.
- Phosphorus-based plan implementation will be required on farms using chemical fertilizer beginning December 31,2002 and on farms using manure or biosolids by July 1, 2005.
- Up to 87.5% cost share is available for development of nutrient management plans and up to $20 per ton cost share assistance with costs of manure transportation are available. Implementation of projects assisted by this funding has the potential to move nutrients to sites where they are needed.

REFERENCES

1. DNR. *Internet Site:* *www.dnr.state.md.us/* . Source areas from the site: *Surf Your Watershed; Chesapeake Bay Tributary Strategies; Information Resource Center / Publications / Data*. Accessed September 2002.

2. Clean Water Action Plan Technical Workgroup. *Maryland Clean Water Action Plan.* December 1998. www.dnr.state.md.us/cwap/ Accessed September 2002.

3. Department of State Documents Internet Site: www.dsd.state.md.us

4.MDE. *Draft Maryland's 2000 303(d) List.* Internet site accessed September 2002. http://www.mde.state.md.us/tmdl/2002_303dlist/2002_303d_draft.html

5. MDE. www.mde.state.md.us/tmdl/ Accessed September 2002.

6. National Academy of Sciences. *Clean Coastal Waters: Understanding and Reducing The Effects of Nutrient Pollution.* National Academy Press. 2000.

7. Harford County Dept. of Public Works. *Bynum Run Stream Survey (Winter 1995-1996).* CBWP-MANTA-EA-97-3 December 1999. 66 pages plus numerous maps and appendices.

8. Harford County Dept. of Planning and Zoning. *Bush River Management Plan.* 1985. 71 pages.

9. Harford County. *Bush River Water Quality Completion Report.* Prepared by CH2M Hill. March 1983. 198 pages.

10. Ludwig, W.H. Jr. *1987 Bush River Survey Project.* Harford County Depart. of Public Works. 41 pages.

11. Glasser, M.B. *The Bush River In The Main-Stream of America.* Harford County Health Dept. Division of Environmental Hygeine. 1965. 18 pages.

12. Kollar, S.A. F.M. Grimm and Dr. N. Friedman. *The Bush River Watershed Water Quality Monitoring Program Final Report.* Submitted to the Harford County Dept. of Planning and Zoning by the Harford Community College Scientific Studies Division. Aug. 1988. 199 pages.

13. Tremper Bowen, J. *The Atkisson Reservoir Study.* Harford County Dept. of Public Works 208 Water Quality Management Program. 140 pages.

14. Pasternack, G.B. *Physical Dynamics of Tidal Freshwater Delta Evolution.* PhD dissertation submitted to The Johns Hopkins University. 1998. 197 pages.

15. Pasternack, G.B., G.S. Brush. *Sedimentation Cycles In A River-Mouth Tidal Freshwater Marsh.* Published in *Estuaries* vol. 21, no. 3, p. 407-415. September 1998. 9 pages.

16. Cornwell, J., L. Pride and M. Owens. *Otter Creek Sediment-Water Exchange Study*. Draft report to the Maryland Dept. of Natural Resources by the University of Maryland Center for Environmental Science Horn Point Laboratory. November 1999. 9 pages.

17. Hilgartner, W. *Plant List At Otter Point Creek.* Compiled 1991-1996 including 1997 update. 6 pages.

18. Boward, D.M., H.M. Dail and P.F. Kazyak. *Bush River Basin Environmental Assessment of Stream Conditions.* Maryland Dept. of Natural Resources Resource Assessment Service. CBWP-MANTA-EA-97-3. December 1997. 88 pages.

19. Ecological Analysts, Inc. *Power Plant Site Evaluation Aquatic Biology Final Report, Perryman Site.* Report prepared for DNR Power Plant Siting Program. Report Number PPSE 2-2. December 1974. 193 pages.

20. Clearwater, Denice. *Nontidal Wetland Impact Data by Watershed Segment (In Acres) 01/01/1991 - 12/31/2001.* Recevied via fax from Maryland Dept. of the Environment April 30, 2002. Four pages.

21. DNR. *Maryland Biological Stream Survey 2000-2004 Volume 1 Ecological Assessment of Watersheds Sampled in 2000.* Chesapeake Bay and Watershed Programs, Monitoring and Nontidal Assessment Division. CBWP-MANTA-EA-01-5. 330 pages.

22. Hurd, Martin. Personal communications on GIS and database data from Maryland Biological Stream Survey. 2001-2002.

23. Maryland Dept. of the Environment Water Supply Program. 2002 information.

24. Johnson, Zoë Pfahl. *A Sea Level Rise Response Strategy For The State Of Maryland.* Document was prepared for Maryland DNR Coastal Zone Management Division. October 2000. 49 pages.

25. State of Maryland Shore Erosion Task Force. *Final Report January 2000.* 64 pages.

26. DNR. *2000 Maryland Section 305(b) Water Quality Report.* August 2000. 194 pages.

27. Ludwig, W.H. Jr. Harford County Dept. of Public Works, Sod Run WWTP. Selected from handouts provided for the Bush River Information Sharing Workshop held November 13, 2001 at the HEAT Center in Aberdeen, Maryland.

28. Gougeon, Charles. Personal communication with the DNR Fisheries Service Central Region Biologist. August 23, 2002.

29. US EPA. The State of the Chesapeake Bay. A Report to the Citizens of the Bay Region. Chesapeake Bay Program. CBP/TRS 260/02. EPA 903-R-02-002. June 2002. Page 23.

30. Ibid. Page 39.

GLOSSARY

303(d)	A section of the federal Clean Water Act requiring the states to report which waters of the state are considered impaired for the uses for which they have been designated, and the reasons for the impairment. Waters included in the "303(d) list" are candidates for having TMDLs developed for them.
319	A section of the federal Clean Water Act dealing with non-point sources of pollution. The number is often used alone as either a noun or an adjective to refer to some aspect of that section of the law, such as grants.
8-digit watershed	Maryland has divided the state into 138 watersheds, each comprising an average of about 75 square miles, that are known as 8-digit watersheds because there are 8 numbers in the identification number each has been given. These nest into the 21 larger 6-digit watersheds in Maryland which are also called Tributary Basins or River Basins. Within the Chesapeake Bay drainage, 8-digit watersheds also nest into 10 Tributary Team Basins.
Anadromous fish	Fish that live most of their lives in salt water but migrate upstream into fresh water to spawn.
Benthic	Living on the bottom of a body of water.
Bush River Basin	The Chesapeake Bay drainage area designated by the State of Maryland and the US EPA as 021307 ("6-digit" watershed). It includes the following 8-digit watesheds: Bush River, Lower Winters Run, Atkisson Reservoir, Bynum Run, Aberdeen Proving Ground and Swan Creek.
Bush River Watershed	The Bush River drainage area designated by the State of Maryland and the US EPA as 02130701 ("8-digit" watershed).
CBIG	Chesapeake Bay Implementation Grant Program, a DNR-administered program that awards grants from the Chesapeake Bay Program to reduce and prevent pollution and to improve the living resources in the Chesapeake Bay.
CBNERR	The Chesapeake Bay National Estuarine Research Reserve in a

	federal, state and local partnership to protect valuable estuarine habitats for research, monitoring and education. The Maryland Reserve has three components: Jug Bay on the Patuxent River in Anne Arundel and Prince Georges' Counties, Otter Point Creek in Harford County and Monie Bay in Somerset County.
CCWS	Chesapeake and Coastal Watershed Service, the unit in DNR that works with local governments and other interested parties to develop restoration strategies and projects.
COMAR	Code Of Maryland Regulations (Maryland State regulations)
CREP	Conservation Reserve Enhancement Program, a program of MDA. CREP is a federal/state and private partnership which reimburses farmers at above normal rental rates for establishing riparian forest or grass buffers, planting permanent cover on sensitive agricultural lands and restoring wetlands for the health of the Chesapeake Bay.
CRP	Conservation Reserve Program, a program of Farm Service Agency in cooperation with local Soil Conservation Districts. CRP encourages farmers to take highly erodible and other environmentally-sensitive farm land out of production for ten to fifteen years.
CWAP	Clean Water Action Plan, promulgated by EPA in 1998. It mandates a statewide assessment of watershed conditions and provides for development of Watershed Restoration Action Strategies (WRASs) for priority watersheds deemed in need of restoration
CWiC	Chesapeake 2000 Agreement watershed commitments. CWiC is a shorthand phrase used in the Chesapeake Bay Program.
CZARA	The Coastal Zone Reauthorization Amendments of 1990, intended to address coastal non-point source pollution. Section 6217 of CZARA established that each state with an approved Coastal Zone Management program must develop and submit a Coastal Non-Point Source program for joint EPA/NOAA approval in order to “develop and implement management measures for NPS pollution to restore and protect coastal waters”.
CZMA	Coastal Zone Management Act of 1972, establishing a program for states and territories to voluntarily develop comprehensive programs to

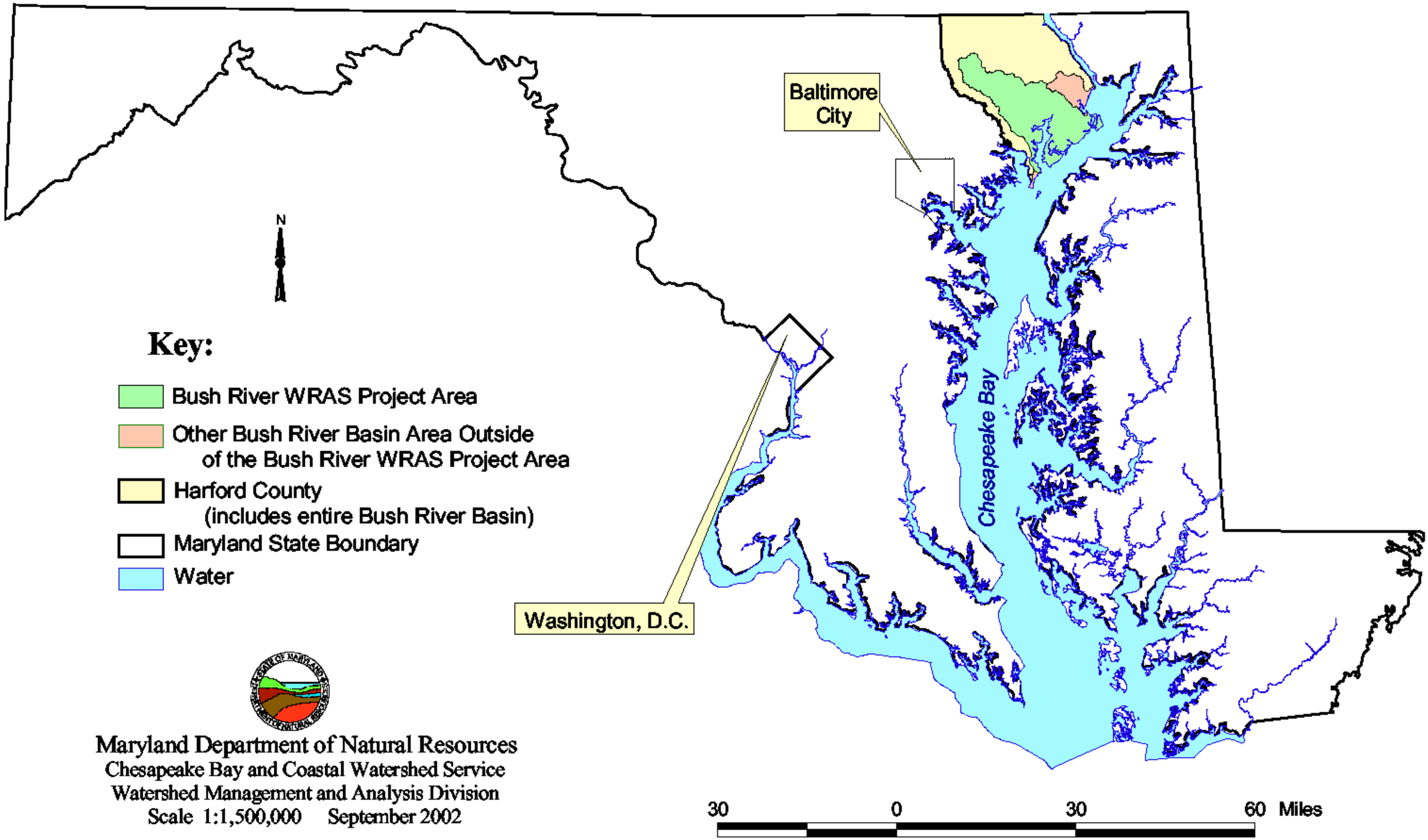
	protect and manage coastal resources (including the Great Lakes). Federal funding is available to states with approved programs.
Conservation Easement	A legal document recorded in the local land records office that specifies conditions and/or restrictions on the use of and title to a parcel of land. Conservation easements run with the title of the land and typically restrict development and protect natural attributes of the parcel. Easements may stay in effect for a specified period of time, or they may run into perpetuity.
DNR	Department of Natural Resources (Maryland State)
EPA	Environmental Protection Agency (United States)
Fish blockage	An impediment, usually man-made, to the migration of fish in a stream, such as a dam or weir, or a culvert or other structure in the stream
GIS	Geographic Information System, a computerized method of capturing, storing, analyzing, manipulating and presenting geographical data.
MBSS	Maryland Biological Stream Survey, a program in DNR that samples small streams throughout the state to assess the condition of their living resources.
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MET	Maryland Environmental Trust, an organization that holds conservation easements on private lands and assists local land trusts to do similar land protection work.
MGS	Maryland Geological Survey, a division in DNR.
NHA	Natural Heritage Area, a particular type of DNR land holding, designated in COMAR.
NOAA	National Oceanic and Atmospheric Administration, an agency of the US Department of Commerce that, among other things, supports the Coastal Zone Management program, a source of funding for some local environmental activities, including restoration work.

NPS	Non-Point Source, pollution that originates in the landscape that is not collected and discharged through an identifiable outlet.
NRCS	Natural Resources Conservation Service, formerly the Soil Conservation Service, an agency of the US Department of Agriculture that, through local Soil Conservation Districts, provides technical assistance to help farmers develop conservation systems suited to their land. NRCS participates as a partner in other community-based resource protection and restoration efforts.
PDA	Public Drainage Association
Palustrine Wetlands	Fresh water wetlands, including bogs, marshes and shallow ponds.
RAS	Resource Assessment Service, a unit of DNR that carries out a range of monitoring and assessment activities affecting the aquatic environment.
Riparian Area	1. Land adjacent to a stream. 2. Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e. a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes, and estuarine-marine shorelines. (National Research Council, *Riparian Areas: Functions and Strategies for Management*. Executive Summary page 3. 2002)
SAV	Submerged Aquatic Vegetation, important shallow-water sea grasses that serve as a source of food and shelter for many species of fin- and shell-fish.
SCA[M]	Stream Corridor Assessment is an activity carried out by CCWS in support of WRAS development and other management needs, in which trained personnel walk up stream channels noting important physical features and possible sources of problems.
SCD	Soil Conservation District is a county-based, self-governing body whose purpose is to provide technical assistance and advice to farmers and landowners on the installation of soil conservation practices and the

	management of farmland to prevent erosion.
SSPRA	Sensitive Species Protection Review Area, an imprecisely defined area in which DNR has identified the occurrence of rare, threatened and/or endangered species of plants or animals, or of other important natural resources such as rookeries and waterfowl staging areas.
Synoptic survey	A short term sampling of water quality and analysis of those samples to measure selected water quality parameters. A synoptic survey as performed by DNR in support of watershed planning may be expanded to include additional types of assessment like benthic macroinvertibrate sampling or physical habitat assessment.
TMDL	Total Maximum Daily Load, a determination by MDE of the upper limit of one or more pollutants that can be added to a particular body of water beyond which water quality would be deemed impaired.
Tributary Teams	Geographically-focused groups, appointed by the Governor, oriented to each of the 10 major Chesapeake Bay tributary basins found in Maryland. The teams focus on policy, legislation, hands-on implementation of projects, and public education. Each basin has a plan, or Tributary Strategy.
USFWS	United States Fish and Wildlife Service, an agency of the Department of Interior.
USGS	United States Geological Survey
Water Quality Standard	Surface water quality standards consist of two parts: (a) designated uses of each water body; and (b) water quality criteria necessary to support the designated uses. Designated uses of for all surface waters in Maryland (like shell fish harvesting or public water supply) are defined in regulation. Water quality criteria may be qualitative (like "no objectionable odors") or quantitative (toxic limitations or dissolved oxygen requirements).
Watershed	All the land that drains to an identified body of water or point on a stream.
WRAS	Watershed Restoration Action Strategy, a document outlining the condition of a designated watershed, identifying problems and

	commiting to solutions of prioritized problems.
WSSC	Wetland of Special State Concern, a designation by MDE in COMAR.

Map 1 Regional Context
Bush River Watershed Restoration Action Strategy (WRAS) Area
In Harford County, Maryland



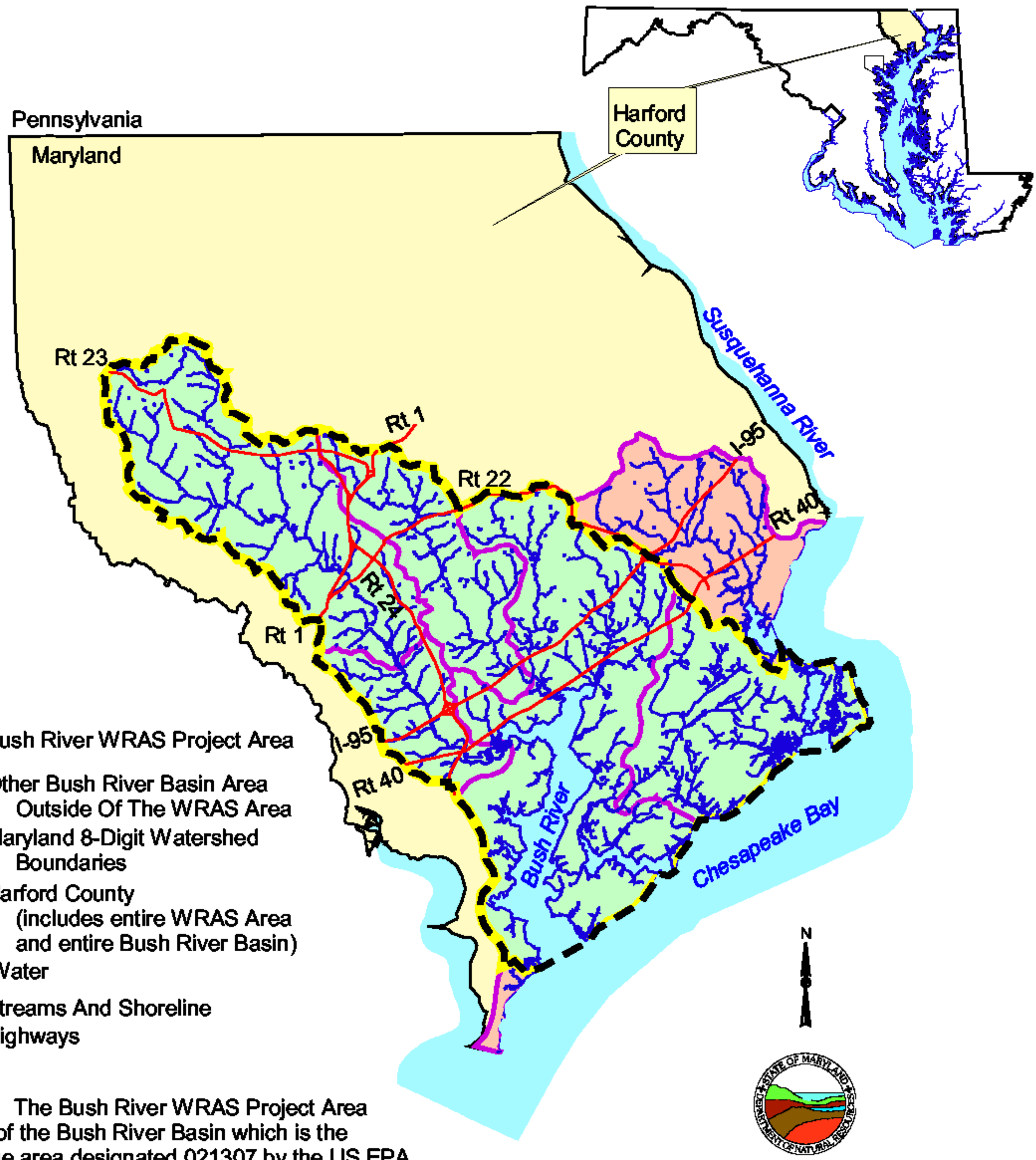
Key:

- Bush River WRAS Project Area
- Other Bush River Basin Area Outside of the Bush River WRAS Project Area
- Harford County (includes entire Bush River Basin)
- Maryland State Boundary
- Water

Maryland Department of Natural Resources
Chesapeake Bay and Coastal Watershed Service
Watershed Management and Analysis Division

Scale 1:1,500,000 September 2002

Map 2 Bush River WRAS Project Area
Harford County, Maryland



NOTE: The Bush River WRAS Project Area is part of the Bush River Basin which is the drainage area designated 021307 by the US EPA Chesapeake Bay Program and the State of Maryland. The remaining portions of the Bush River Basin are shown as "Other Bush River Basin Area" in the map.

Maryland Department of Natural Resources
Chesapeake and Coastal Watershed Service
Watershed Management and Analysis Division
1:300,000 scale September 2002

Map 3 Streams and Watersheds
Bush River Basin 021307

East Branch Winters Run 02130703-1134

West Branch Winters Run 02130703-1133

Atkinson Reservoir (Middle Winters Run) 02130703-1132

Bynum Run 02130704-1131

Bush R. Headwaters 02130701-1129

Swan Creek 02130706-1135

Havre de Grace

Bel Air

Aberdeen

Bay Direct at Swan Cr. 02130706-1136

Bush River WRAS Area
Maryland 8-Digit Watershed Boundary
Maryland 12-Digit Watershed Boundary
Harford County Boundary
Water
Streams and Shoreline
Highways and Roads

Lower Winters Run 02130702-1130

Bush River West Bank 02130701-1127

Bush River

Chesapeake Bay

APG Bay Direct 02130705-1125

APG Headwaters 02130705-1126

Bush River East Bank 02130701-1128

APG Bay Direct 02130705-1124

N

2 0 2 4 Miles

Maryland Department of Natural Resources
Chesapeake and Coastal Watershed Service
Scale 1:200,000 September 2002

Map 4 Category 1 Priority Watersheds
Bush River Basin 021307

East Branch Winters Run 02130703-1134

West Branch Winters Run 02130703-1133

Atkinson Reservoir (Middle Winters Run) 02130703-1132

Bynum Run 02130704-1131

Bush R. Headwaters 02130701-1129

Swan Creek 02130706-1135

Havre de Grace

Bel Air

Aberdeen

Bay Direct at Swan Cr. 02130706-1136

Lower Winters Run 02130702-1130

Bush River West Bank 02130701-1127

Bush River East Bank 02130701-1128

APG Bay Direct 02130705-1125

APG Headwaters 02130705-1126

APG Bay Direct 02130705-1124

Bush River

Chesapeake Bay

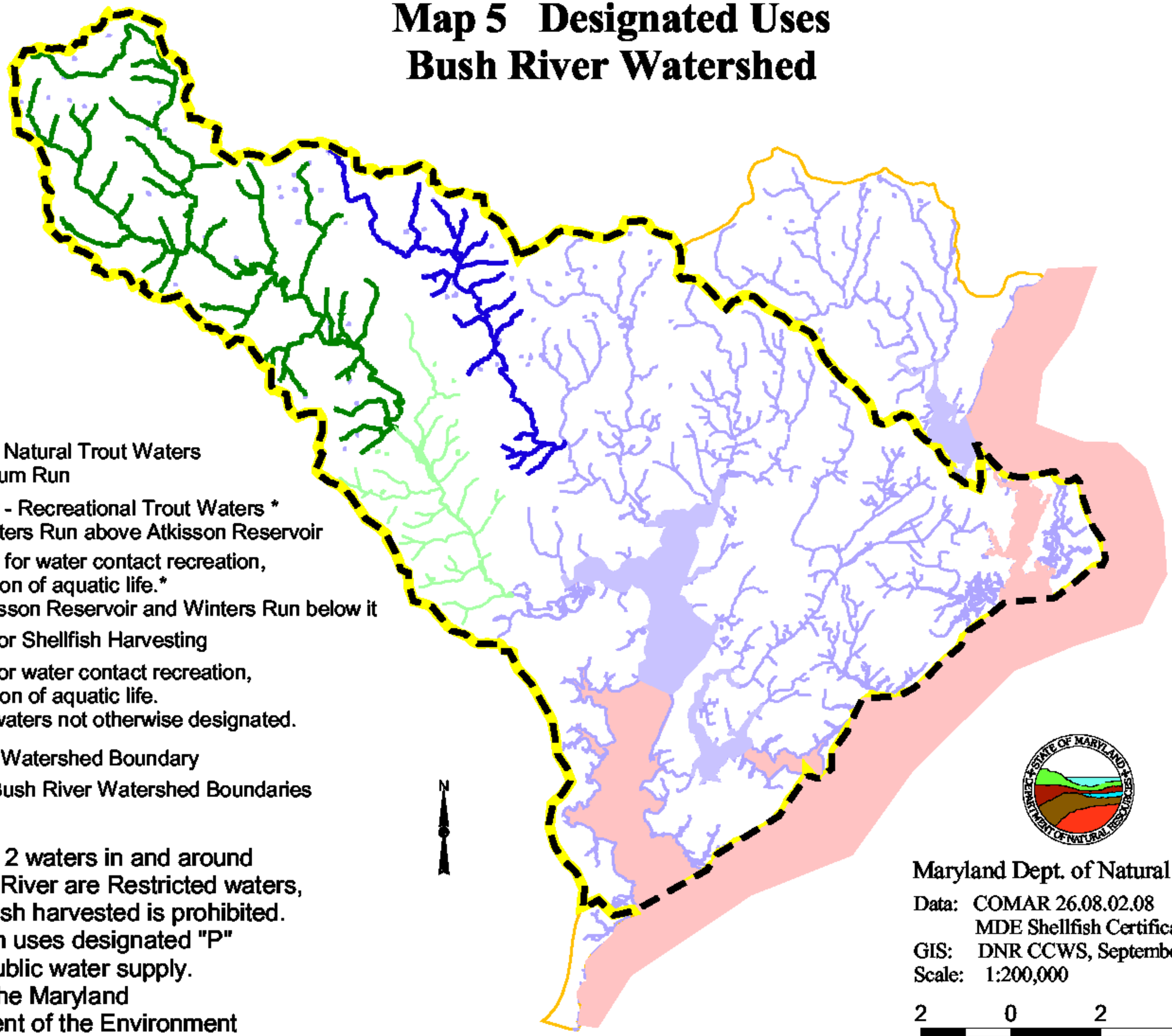
Category 1 Priority Watersheds
8-digit Watershed Boundary
12-digit Watershed Boundary
Federal Land
Water and Streams
Highways and Roads

N

2 0 2 4 Miles

Maryland Department of Natural Resources
Chesapeake and Coastal Watershed Service
Scale 1:200,000 September 2002

Map 5 Designated Uses
Bush River Watershed



- Use 3 - Natural Trout Waters
  - Bynum Run
- Use 4P - Recreational Trout Waters *
  - Winters Run above Atkisson Reservoir
- Use 1P for water contact recreation, protection of aquatic life.*
  - Atkisson Reservoir and Winters Run below it
- Use 2 for Shellfish Harvesting
- Use 1 for water contact recreation, protection of aquatic life.
  - All waters not otherwise designated.
- WRAS Watershed Boundary
- Other Bush River Watershed Boundaries

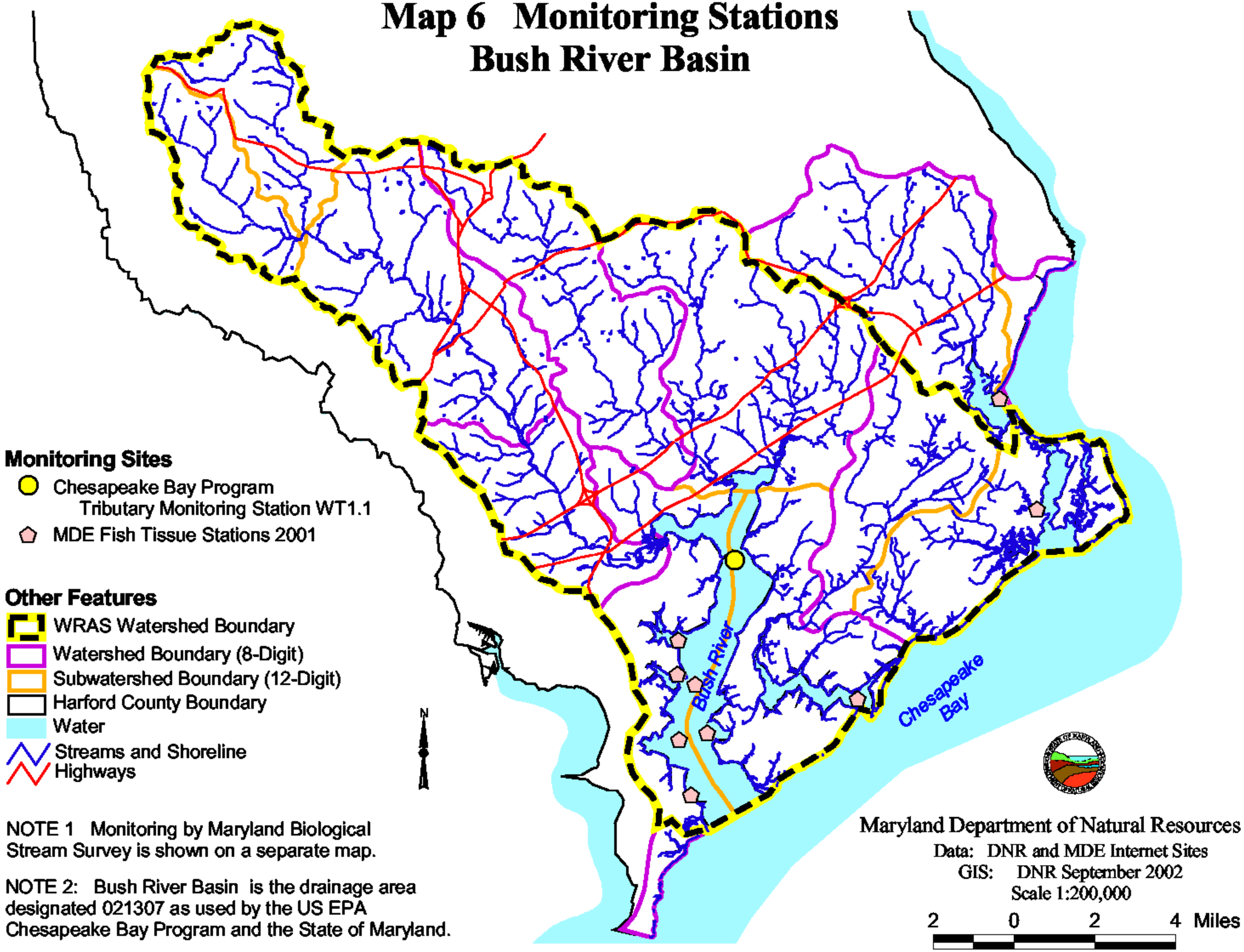
* All Use 2 waters in and around the Bush River are Restricted waters, i.e. shellfish harvested is prohibited. All stream uses designated "P" protect public water supply. Contact the Maryland Department of the Environment for official regulatory information.

Maryland Dept. of Natural Resources

Data: COMAR 26.08.02.08
MDE Shellfish Certification Div.
GIS: DNR CCWS, September 2002
Scale: 1:200,000

2 0 2 4 Miles

Map 6 Monitoring Stations
Bush River Basin



Monitoring Sites

- Chesapeake Bay Program Tributary Monitoring Station WT1.1
- MDE Fish Tissue Stations 2001

Other Features

- WRAS Watershed Boundary
- Watershed Boundary (8-Digit)
- Subwatershed Boundary (12-Digit)
- Harford County Boundary
- Water
- Streams and Shoreline
- Highways

NOTE 1 Monitoring by Maryland Biological Stream Survey is shown on a separate map.

NOTE 2: Bush River Basin is the drainage area designated 021307 as used by the US EPA Chesapeake Bay Program and the State of Maryland.

Maryland Department of Natural Resources

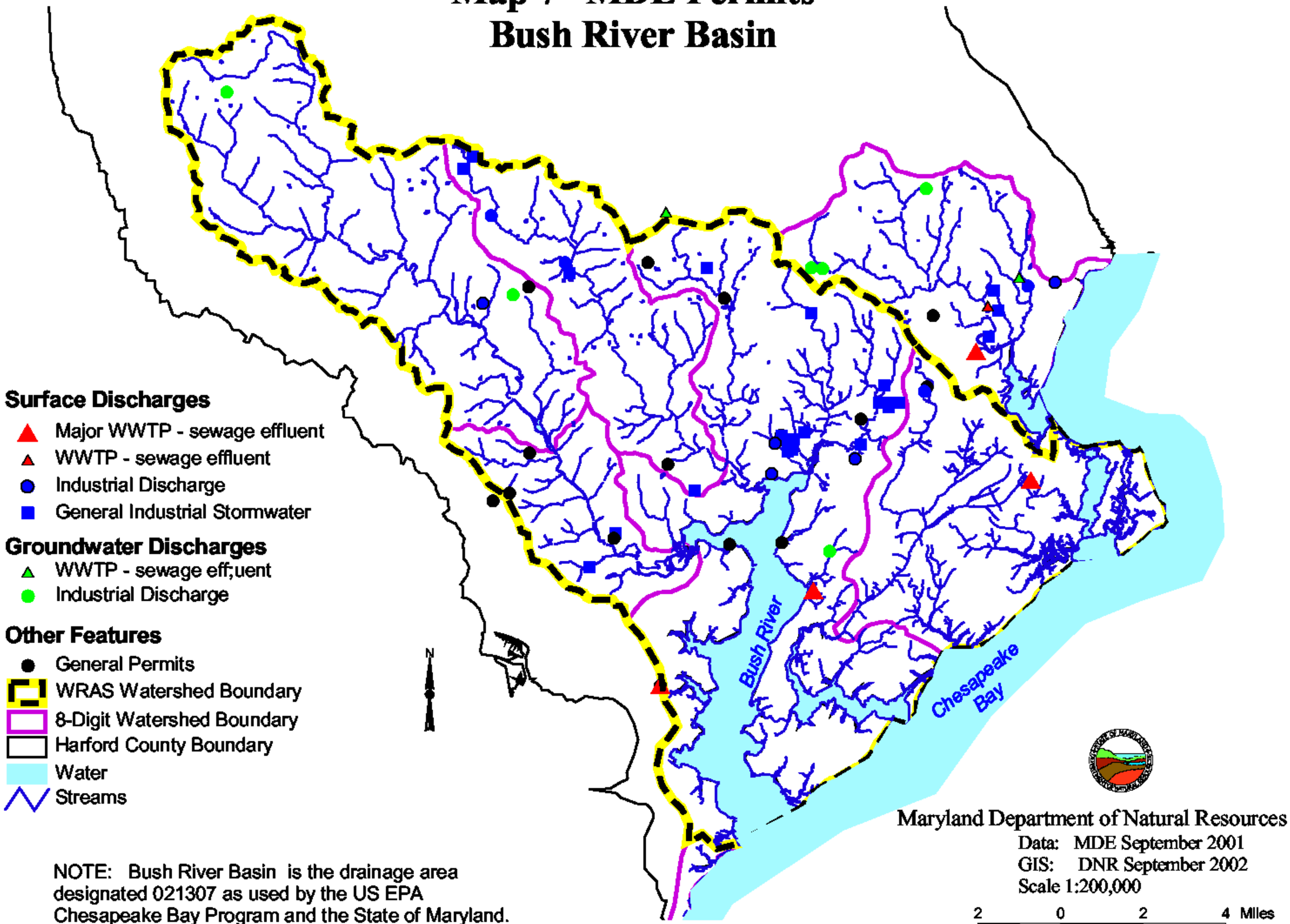
Data: DNR and MDE Internet Sites

GIS: DNR September 2002

Scale 1:200,000

2 0 2 4 Miles

Map 7 MDE Permits
Bush River Basin



Surface Discharges
- Major WWTP - sewage effluent
- WWTP - sewage effluent
- Industrial Discharge
- General Industrial Stormwater

Groundwater Discharges
- WWTP - sewage eff;uent
- Industrial Discharge

Other Features
- General Permits
- WRAS Watershed Boundary
- 8-Digit Watershed Boundary
- Harford County Boundary
- Water
- Streams

NOTE: Bush River Basin is the drainage area designated 021307 as used by the US EPA Chesapeake Bay Program and the State of Maryland.

Maryland Department of Natural Resources
Data: MDE September 2001
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 8 Water Supply
Bush River Basin

Community Groundwater Systems
- Campus Hills Water Works
- City Of Aberdeen
- Fountain Green M.H.P.
- Greenridge Subdivision
- Harford County D.P.W.
- Lakeside Vista
- Maryland American Water Co.

Community Surface Water Systems
- APG Edgewood
- Maryland American Water Co.

- Well Head Protection Area
- WRAS Watershed Boundary
- Bush River Basin 8-Digit Watersheds
- Harford County Boundary
- Water
- Waterways

Bush River

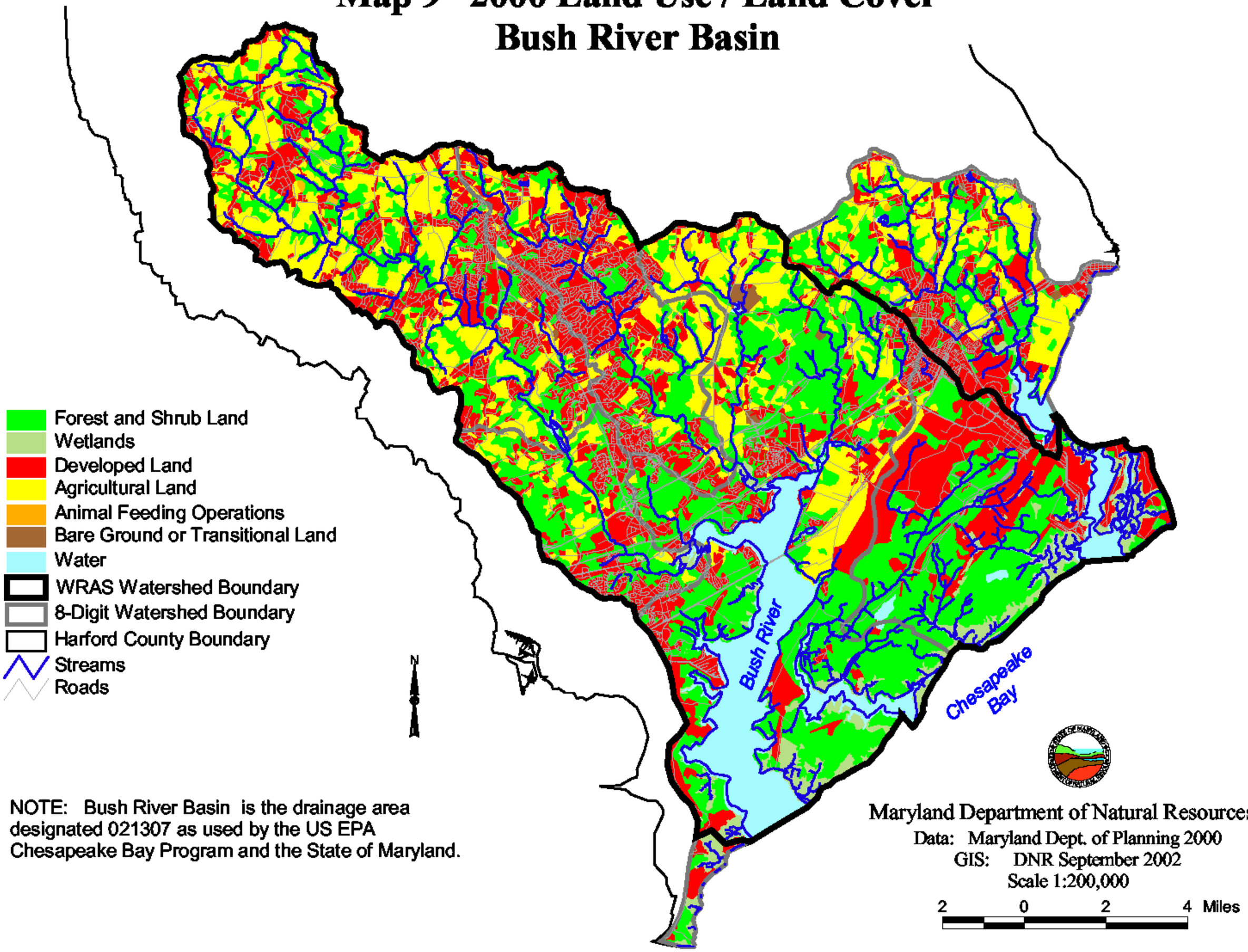
Chesapeake Bay

N

Maryland Department of Natural Resources
Data: MDE, Water Supply Division, March 2002
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 9 2000 Land Use / Land Cover
Bush River Basin

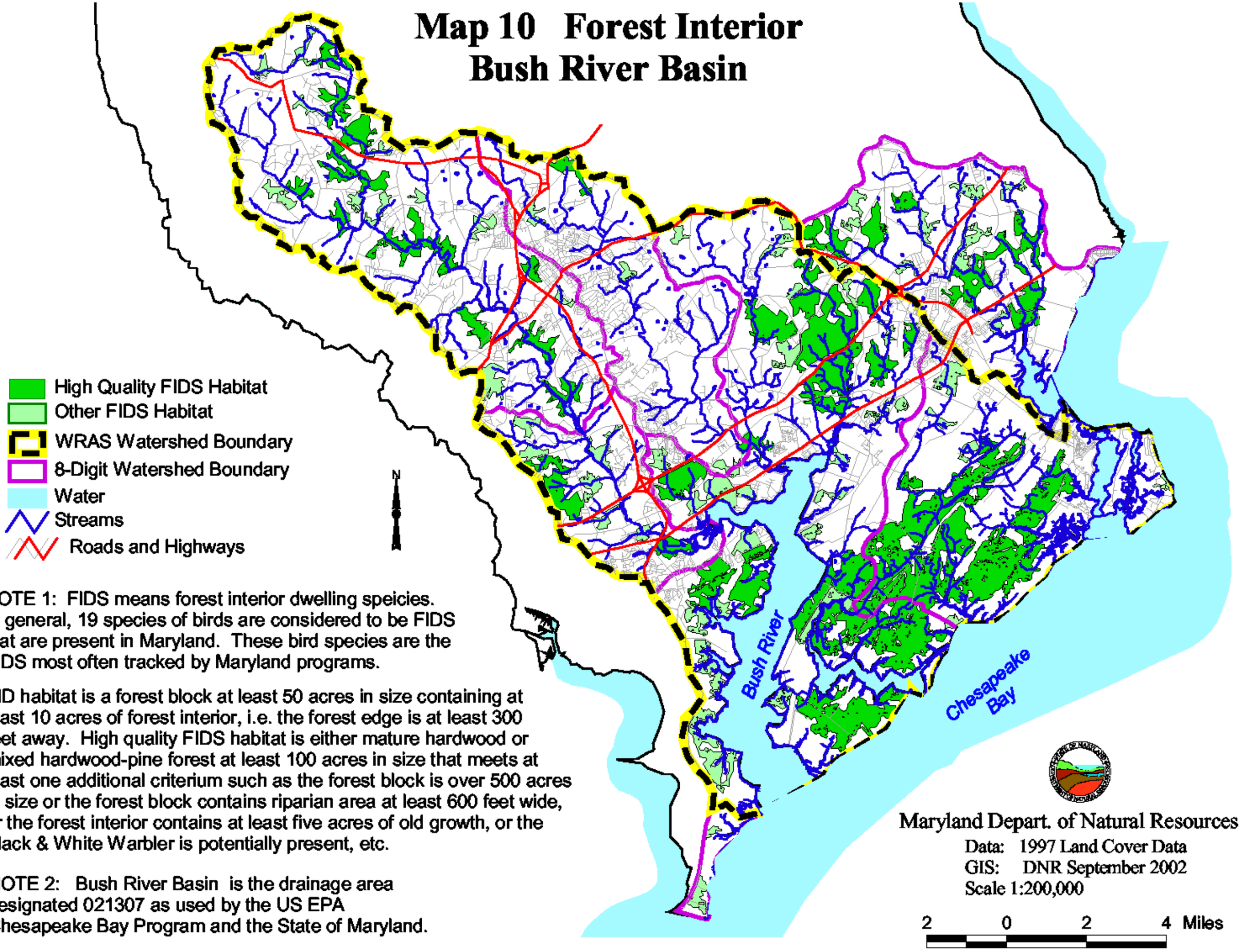


NOTE: Bush River Basin is the drainage area designated 021307 as used by the US EPA Chesapeake Bay Program and the State of Maryland.

Maryland Department of Natural Resources
Data: Maryland Dept. of Planning 2000
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 10 Forest Interior
Bush River Basin



NOTE 1: FIDS means forest interior dwelling speicies. In general, 19 species of birds are considered to be FIDS that are present in Maryland. These bird species are the FIDS most often tracked by Maryland programs.

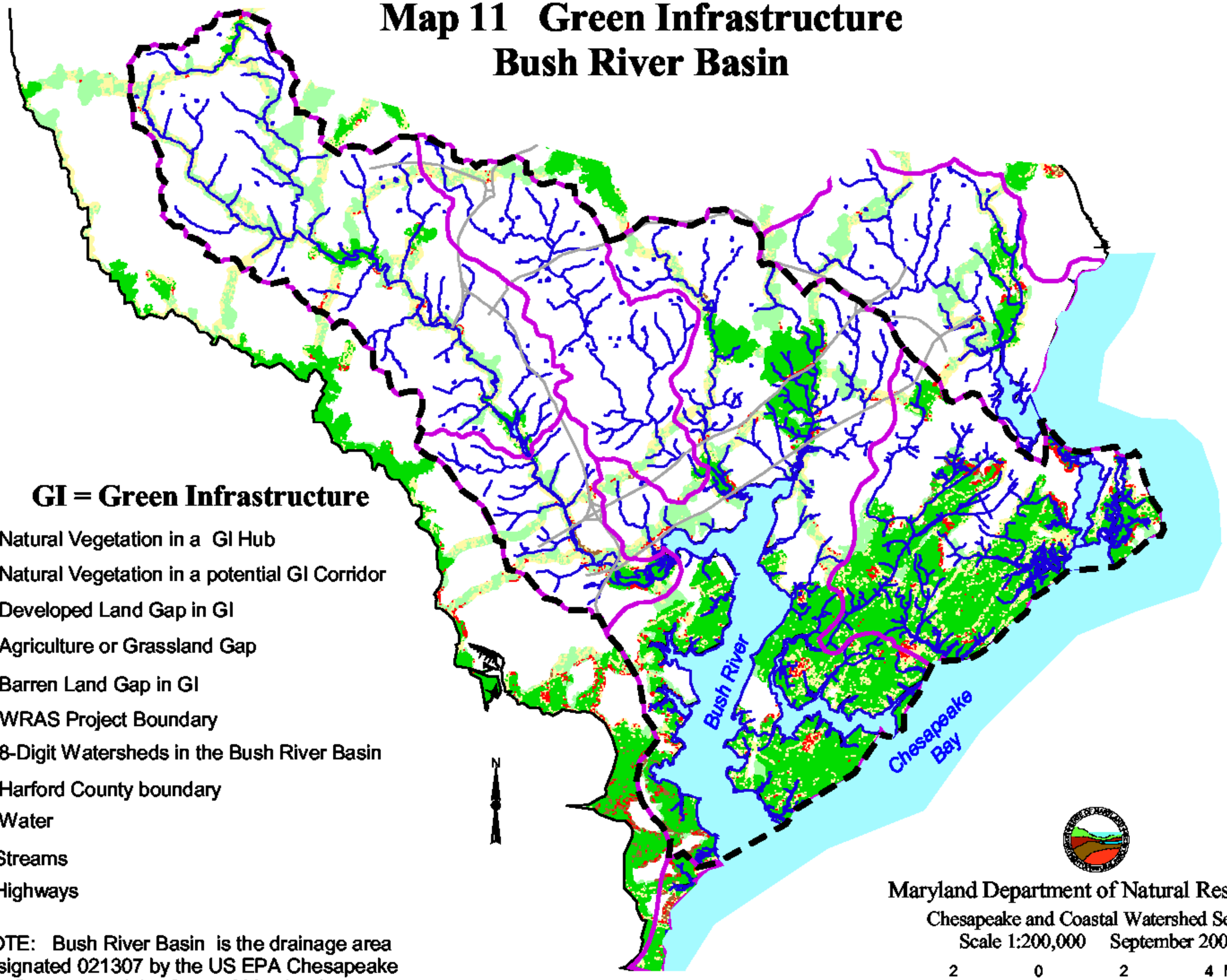
FID habitat is a forest block at least 50 acres in size containing at least 10 acres of forest interior, i.e. the forest edge is at least 300 feet away. High quality FIDS habitat is either mature hardwood or mixed hardwood-pine forest at least 100 acres in size that meets at least one additional criterium such as the forest block is over 500 acres in size or the forest block contains riparian area at least 600 feet wide, or the forest interior contains at least five acres of old growth, or the Black & White Warbler is potentially present, etc.

NOTE 2: Bush River Basin is the drainage area designated 021307 as used by the US EPA Chesapeake Bay Program and the State of Maryland.

Maryland Depart. of Natural Resources
Data: 1997 Land Cover Data
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 11 Green Infrastructure
Bush River Basin



Key GI = Green Infrastructure

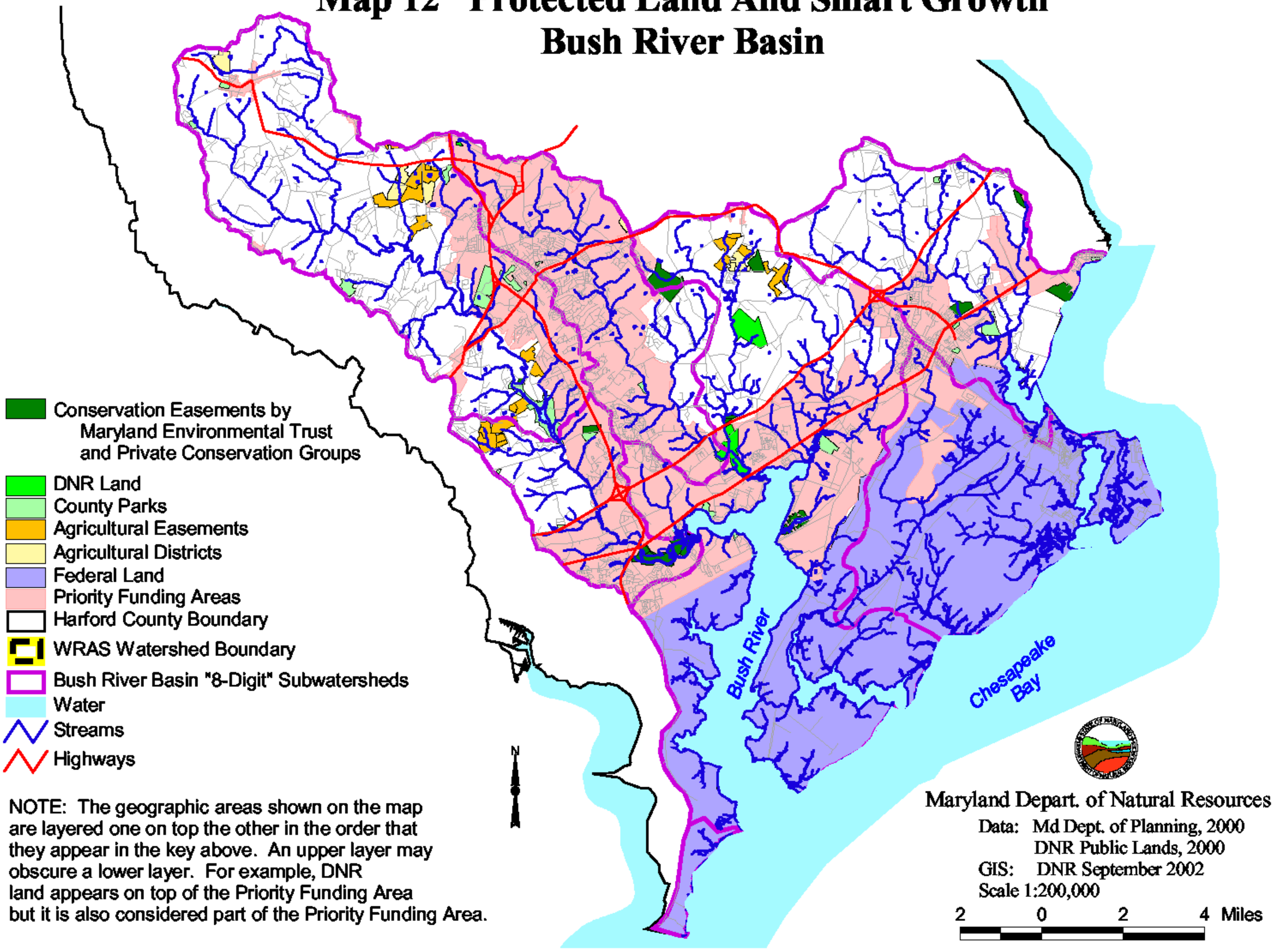
- Natural Vegetation in a GI Hub
- Natural Vegetation in a potential GI Corridor
- Developed Land Gap in GI
- Agriculture or Grassland Gap
- Barren Land Gap in GI
- WRAS Project Boundary
- 8-Digit Watersheds in the Bush River Basin
- Harford County boundary
- Water
- Streams
- Highways

NOTE: Bush River Basin is the drainage area designated 021307 by the US EPA Chesapeake Bay Program and the State of Maryland.

Maryland Department of Natural Resources
Chesapeake and Coastal Watershed Service
Scale 1:200,000 September 2002

2 0 2 4 Miles

Map 12 Protected Land And Smart Growth
Bush River Basin



- Conservation Easements by Maryland Environmental Trust and Private Conservation Groups
- DNR Land
- County Parks
- Agricultural Easements
- Agricultural Districts
- Federal Land
- Priority Funding Areas
- Harford County Boundary
- WRAS Watershed Boundary
- Bush River Basin "8-Digit" Subwatersheds
- Water
- Streams
- Highways

NOTE: The geographic areas shown on the map are layered one on top the other in the order that they appear in the key above. An upper layer may obscure a lower layer. For example, DNR land appears on top of the Priority Funding Area but it is also considered part of the Priority Funding Area.

Maryland Depart. of Natural Resources

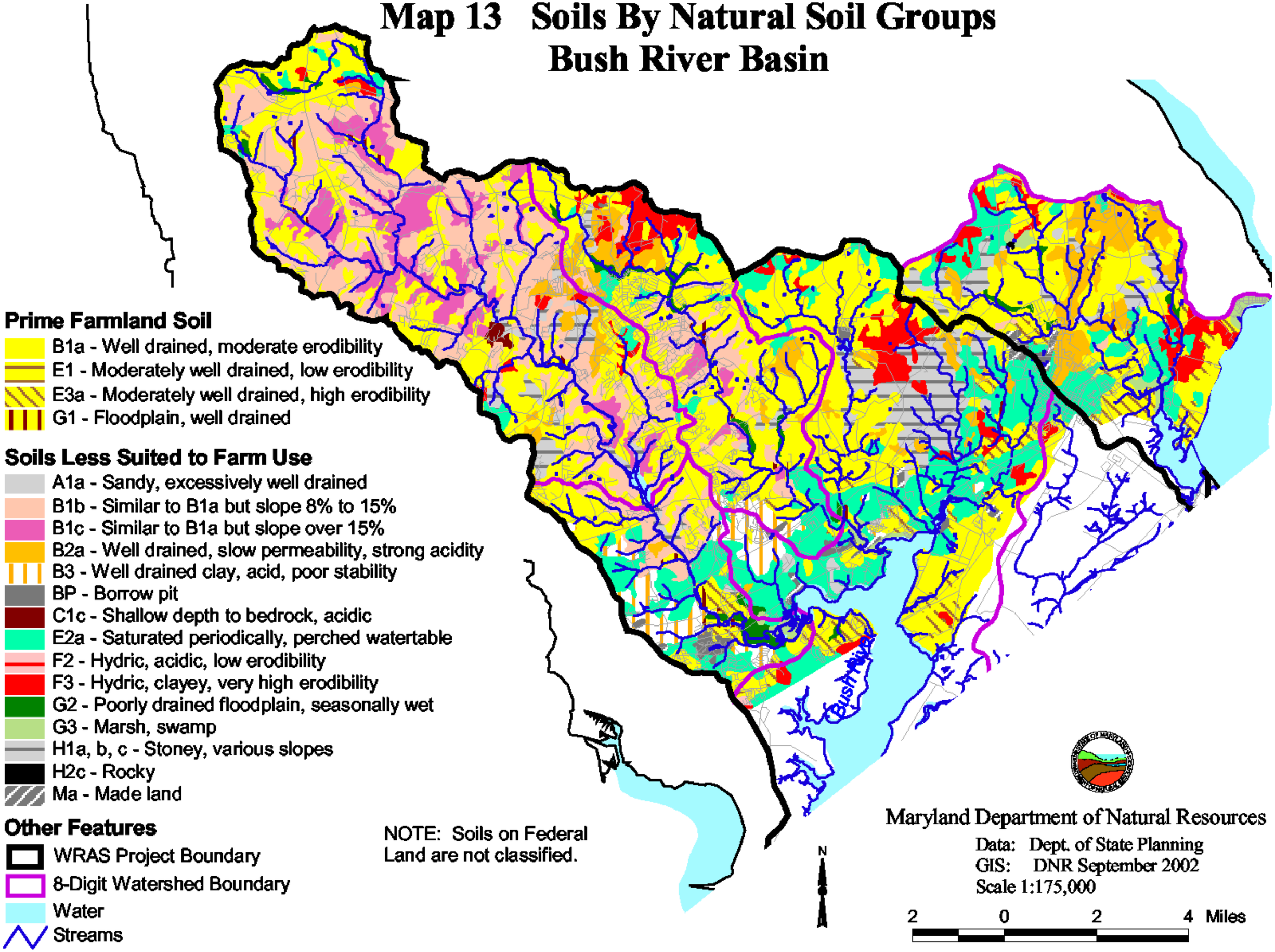
Data: Md Dept. of Planning, 2000
DNR Public Lands, 2000

GIS: DNR September 2002

Scale 1:200,000

2 0 2 4 Miles

Map 13 Soils By Natural Soil Groups
Bush River Basin



Prime Farmland Soil

- B1a - Well drained, moderate erodibility
- E1 - Moderately well drained, low erodibility
- E3a - Moderately well drained, high erodibility
- G1 - Floodplain, well drained

Soils Less Suited to Farm Use

- A1a - Sandy, excessively well drained
- B1b - Similar to B1a but slope 8% to 15%
- B1c - Similar to B1a but slope over 15%
- B2a - Well drained, slow permeability, strong acidity
- B3 - Well drained clay, acid, poor stability
- BP - Borrow pit
- C1c - Shallow depth to bedrock, acidic
- E2a - Saturated periodically, perched watertable
- F2 - Hydric, acidic, low erodibility
- F3 - Hydric, clayey, very high erodibility
- G2 - Poorly drained floodplain, seasonally wet
- G3 - Marsh, swamp
- H1a, b, c - Stoney, various slopes
- H2c - Rocky
- Ma - Made land

Other Features

- WRAS Project Boundary
- 8-Digit Watershed Boundary
- Water
- Streams

NOTE: Soils on Federal Land are not classified.

N

Maryland Department of Natural Resources

Data: Dept. of State Planning
GIS: DNR September 2002
Scale 1:175,000

2 0 2 4 Miles

Map 14 Wetlands In the Bush River Basin

National Wetlands Inventory
Federal Land
WRAS Project Boundary
8-Digit Watershed Boundary
Harford County Boundary
Water
Streams
Highways and Roads

NOTE: Bush River Basin is the drainage area designated 021307 as used by the US EPA Chesapeake Bay Program and the State of Maryland.

N

2 0 2 4 Miles

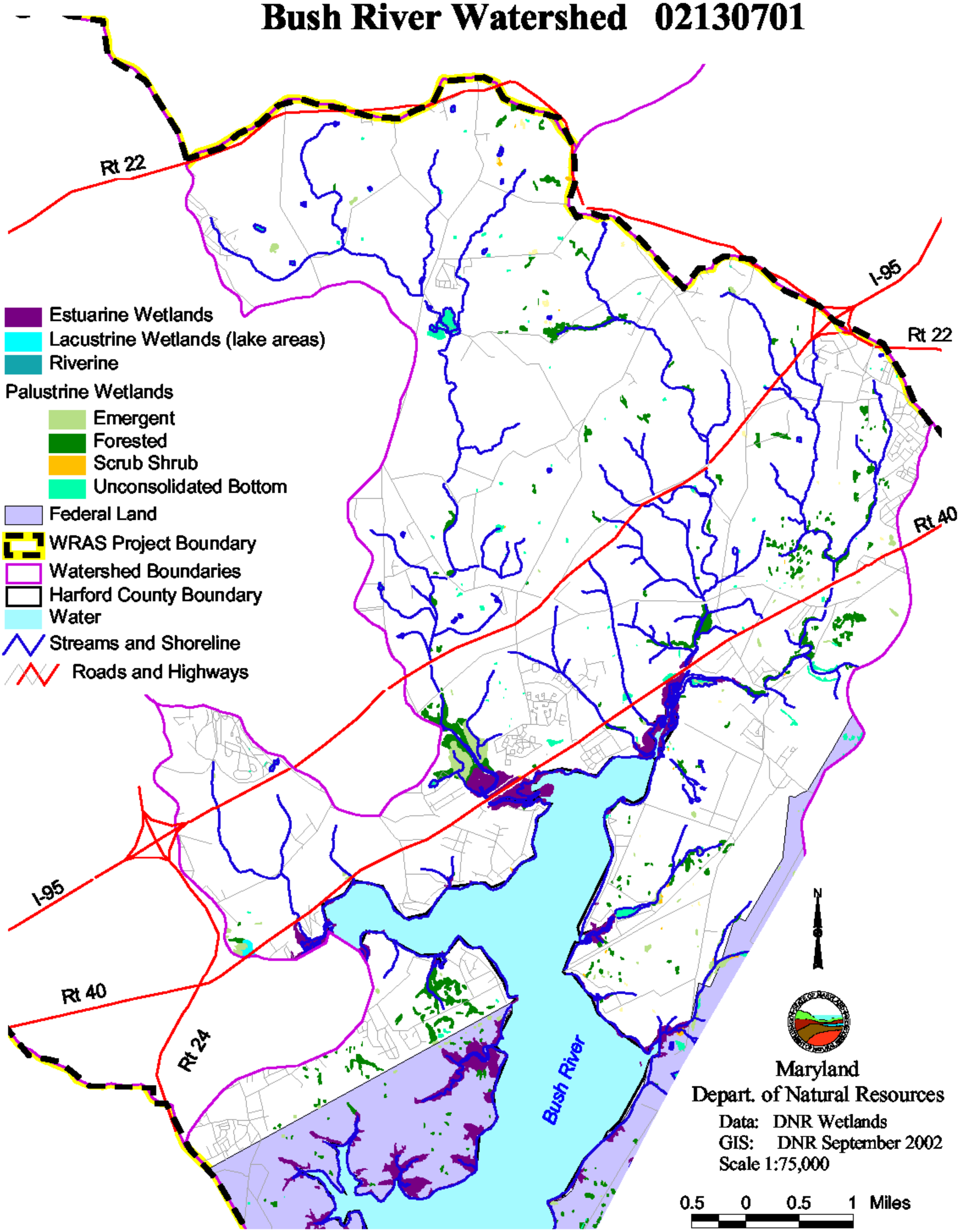
Bush River

Chesapeake Bay

Maryland Department of Natural Resources

Data: National Wetlands Inventory
GIS: DNR September 2002
Scale 1:200,000

Map 15 Wetlands On Non-Federal Land
Bush River Watershed 02130701



Maryland
Depart. of Natural Resources

Data: DNR Wetlands
GIS: DNR September 2002
Scale 1:75,000

0.5 0 0.5 1 Miles

Map 16 Floodplains
Bush River Basin

100-Year Floodplain
500-Year Floodplain
(not identified on Federal land)
Federal Land
WRAS Project Boundary
8-Digit Watershed Boundary
Water
Streams
Highways and Roads

N

Bush River

Chesapeake Bay

NOTE: Bush River Basin is the drainage area designated 021307 by the US EPA Chesapeake Bay Program and the State of Maryland which includes the drainage shown above including the Bush River WRAS Project Area.

Maryland Department of Natural Resources
Data: FEMA 1996
GIS: DNR CCWS September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 17 Benthic Index
Bush River Basin

Benthic Index of Biological Indicators (BIBI)

Year 2000 MBSS Data	Year 2000 Stream Waders Data
Very Poor	Very Poor
Poor	Poor
Fair	Fair
Good	Good

1994 to 1997 MBSS Data

- Poor
- Fair
- Good

- WRAS Project Boundary
- Watershed Boundary (8-digit)
- Subwatershed Boundary (12-digit)
- Harford County Boundary
- Federal Land
- Water
- Streams and Shoreline

NOTES:
MBSS - Maryland Biological Stream Survey
Stream Waders - Volunteers using MBSS protocols

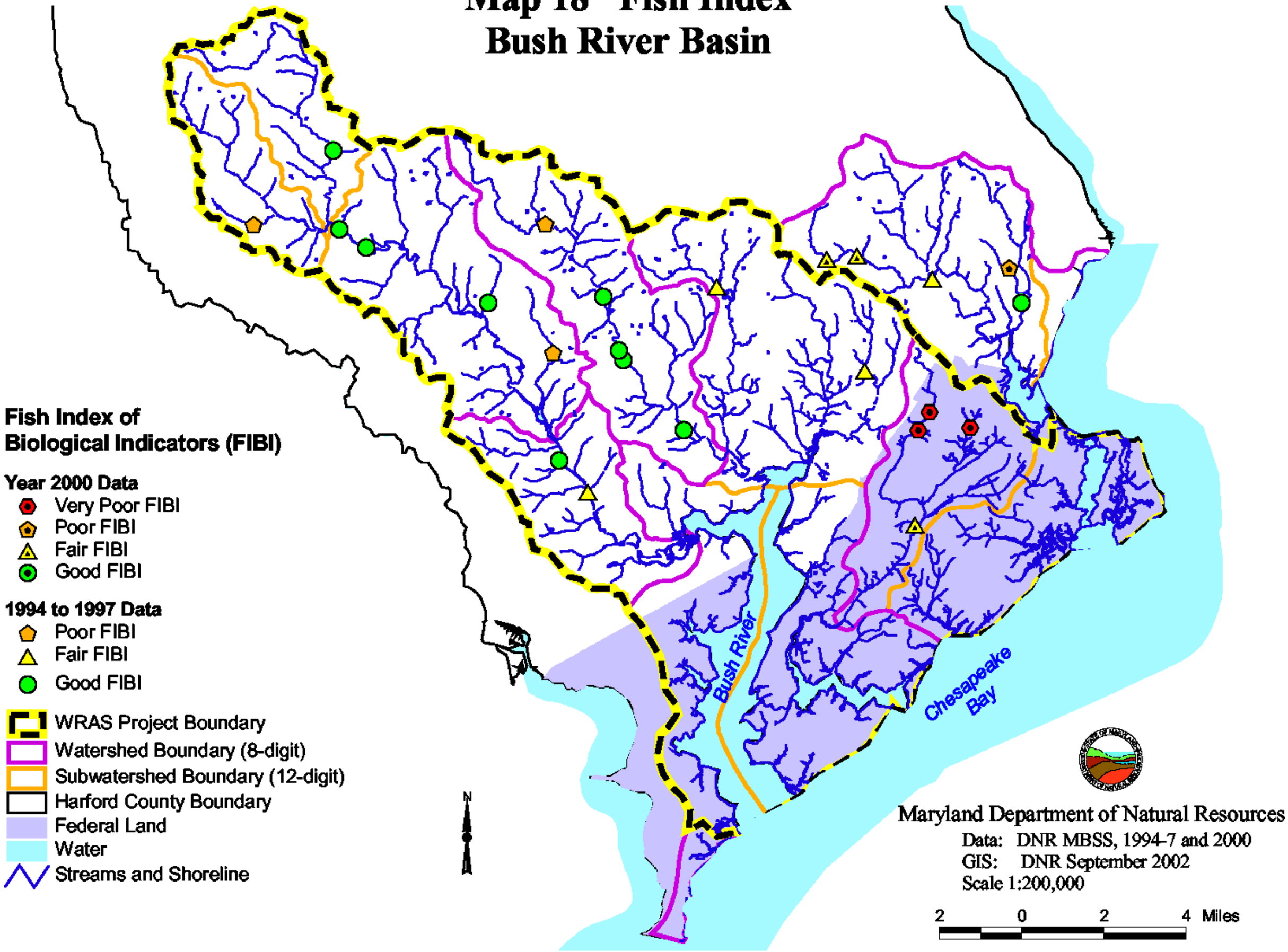
Bush River

Chesapeake Bay

Maryland Department of Natural Resources
Data: DNR MBSS, 1994-7 and 2000
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 18 Fish Index
Bush River Basin



Fish Index of Biological Indicators (FIBI)

Year 2000 Data
- Very Poor FIBI
- Poor FIBI
- Fair FIBI
- Good FIBI

1994 to 1997 Data
- Poor FIBI
- Fair FIBI
- Good FIBI

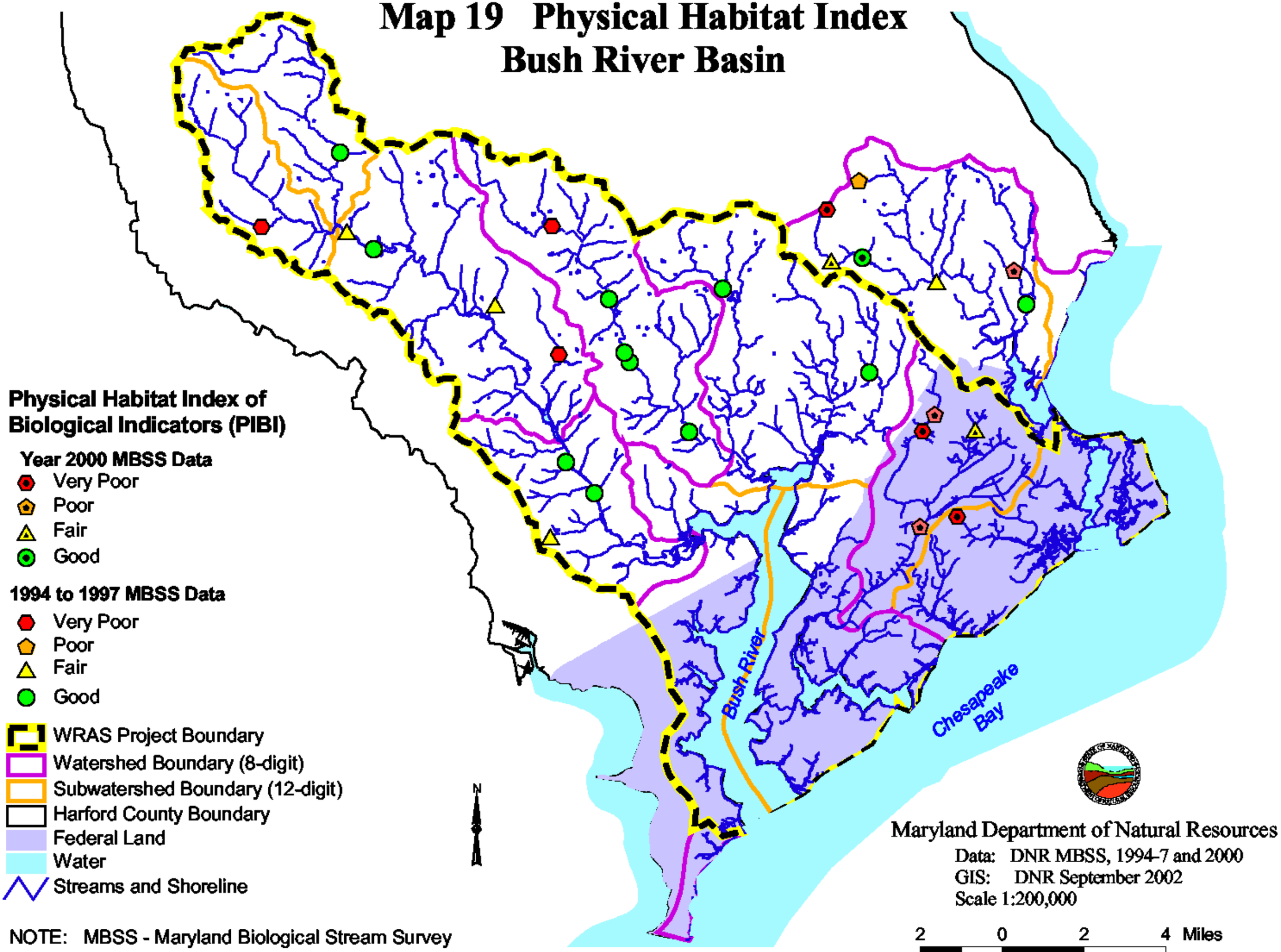
- WRAS Project Boundary
- Watershed Boundary (8-digit)
- Subwatershed Boundary (12-digit)
- Harford County Boundary
- Federal Land
- Water
- Streams and Shoreline

Maryland Department of Natural Resources

Data: DNR MBSS, 1994-7 and 2000
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 19 Physical Habitat Index
Bush River Basin



Physical Habitat Index of Biological Indicators (PIBI)

Year 2000 MBSS Data
- Very Poor
- Poor
- Fair
- Good

1994 to 1997 MBSS Data
- Very Poor
- Poor
- Fair
- Good

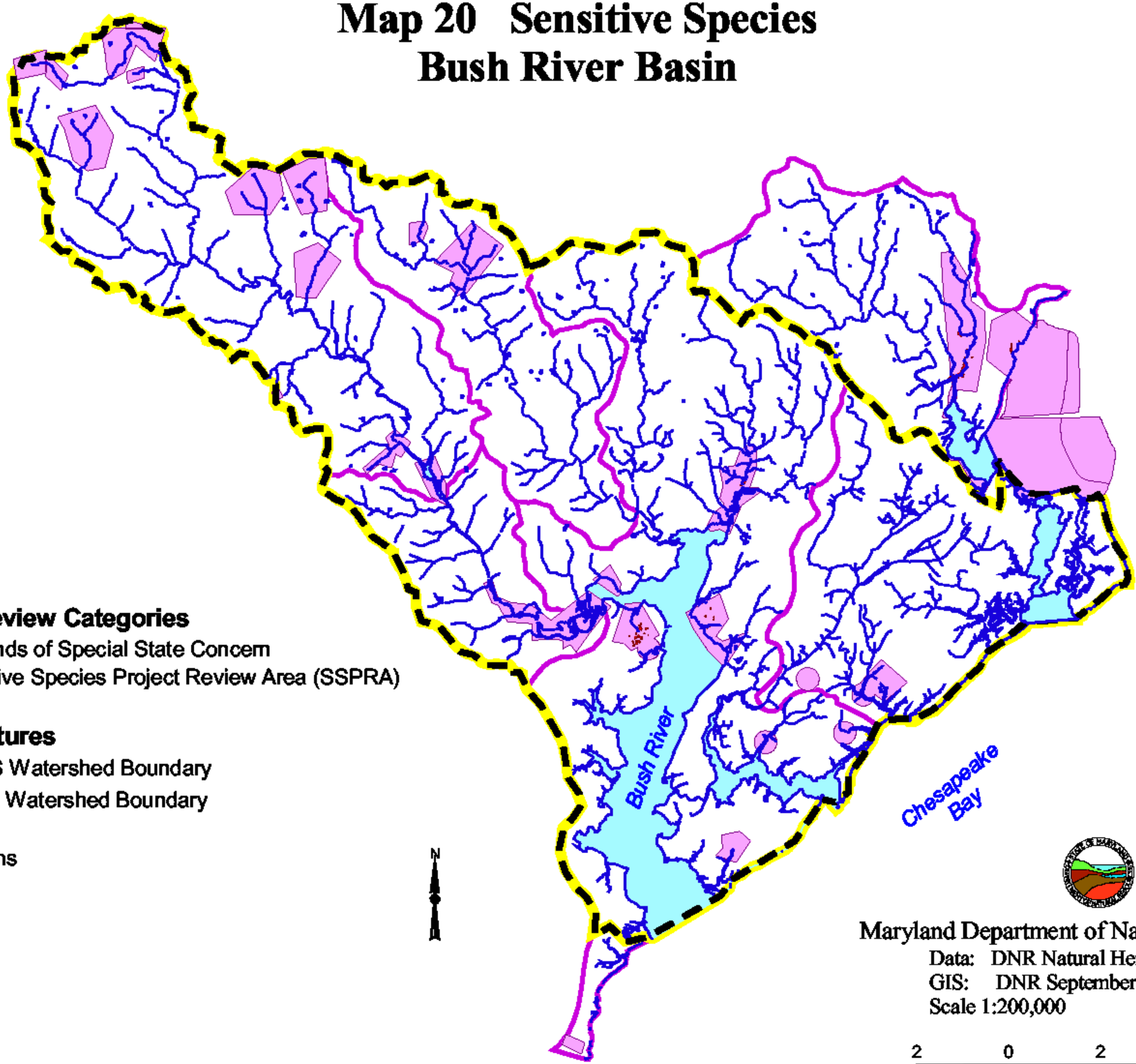
- WRAS Project Boundary
- Watershed Boundary (8-digit)
- Subwatershed Boundary (12-digit)
- Harford County Boundary
- Federal Land
- Water
- Streams and Shoreline

NOTE: MBSS - Maryland Biological Stream Survey

Maryland Department of Natural Resources
Data: DNR MBSS, 1994-7 and 2000
GIS: DNR September 2002
Scale 1:200,000

2 0 2 4 Miles

Map 20 Sensitive Species
Bush River Basin



Project Review Categories

- Wetlands of Special State Concern
- Sensitive Species Project Review Area (SSPRA)

Other Features

- WRAS Watershed Boundary
- 8-Digit Watershed Boundary
- Water
- Streams

Maryland Department of Natural Resources

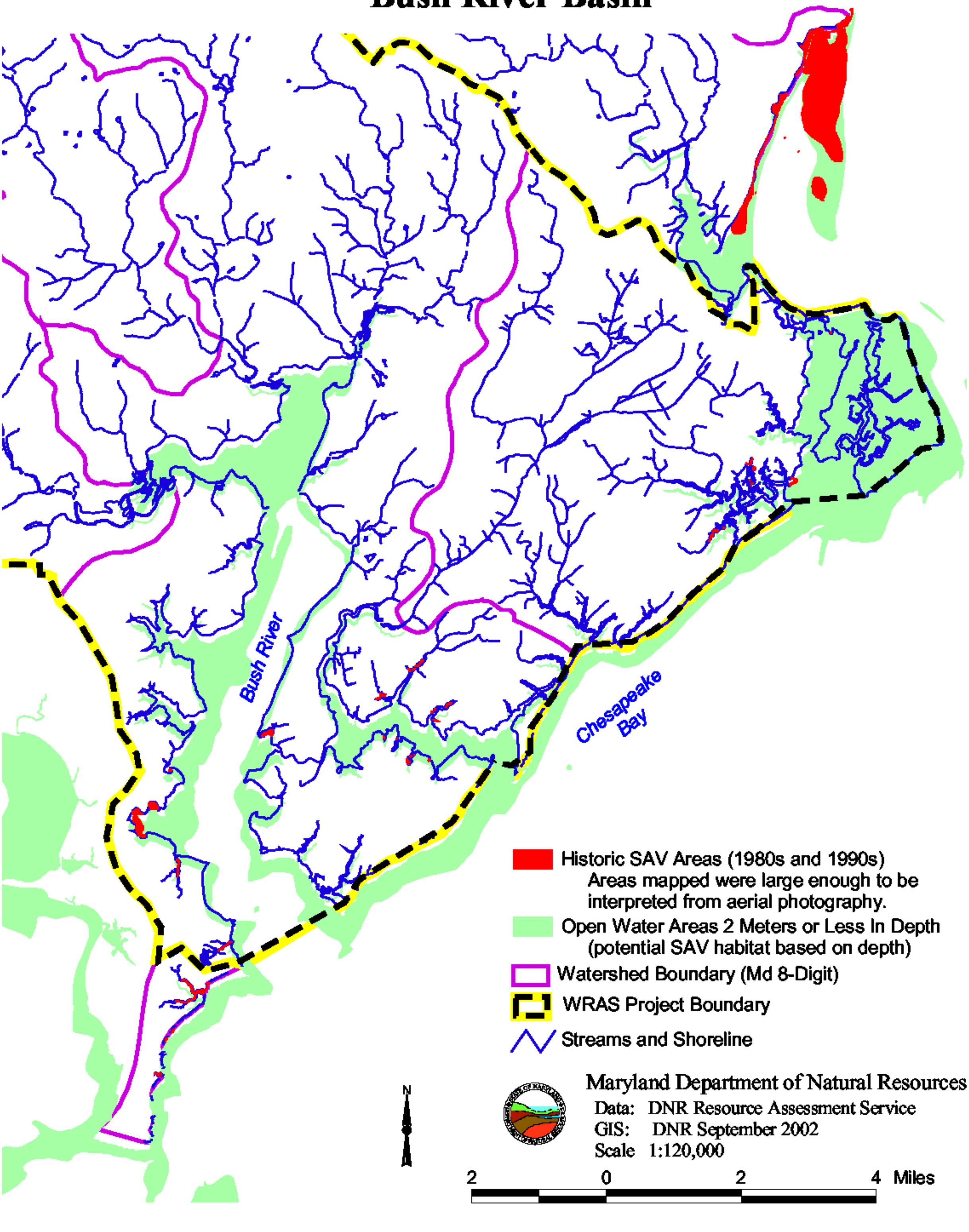
Data: DNR Natural Heritage Prog, 1997

GIS: DNR September 2002

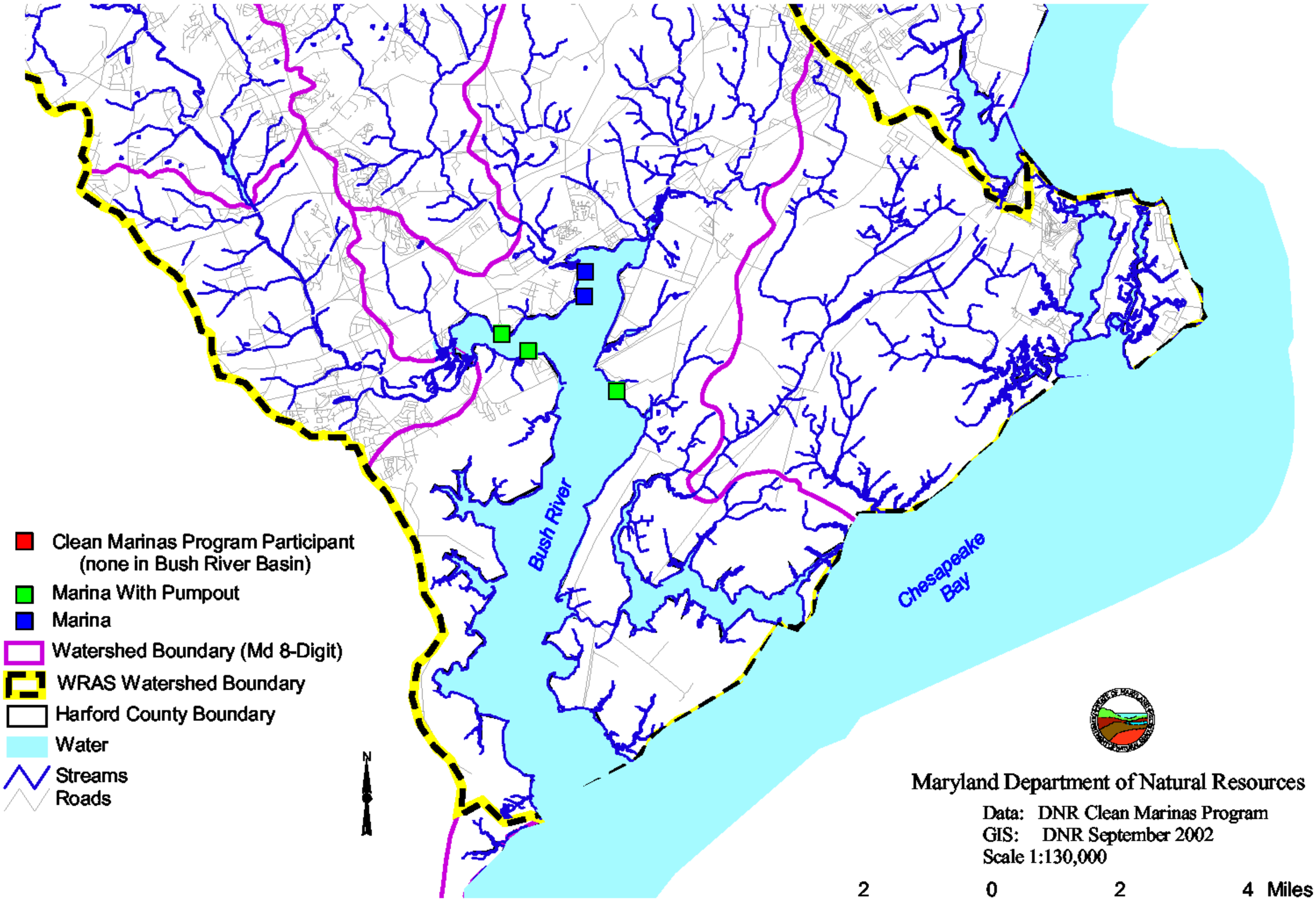
Scale 1:200,000

2 0 2 4 Miles

Map 21 Submerged Aquatic Vegetation
Bush River Basin



Map 22 Marinas In The Bush River Basin



Map 23 Fish Blockages
Bush River Basin

N

Past Blockage Removed

Blockage to Fish Movement
In DNR Fish Blockage Databose does not include information from the Stream Corridor Assessments

WRAS Watershed Boundary

Watershed Boundaries (8-digit)

Harford County Boundary

Water

Streams and Shoreline

Roads

Bush River

Maryland Department of Natural Resources

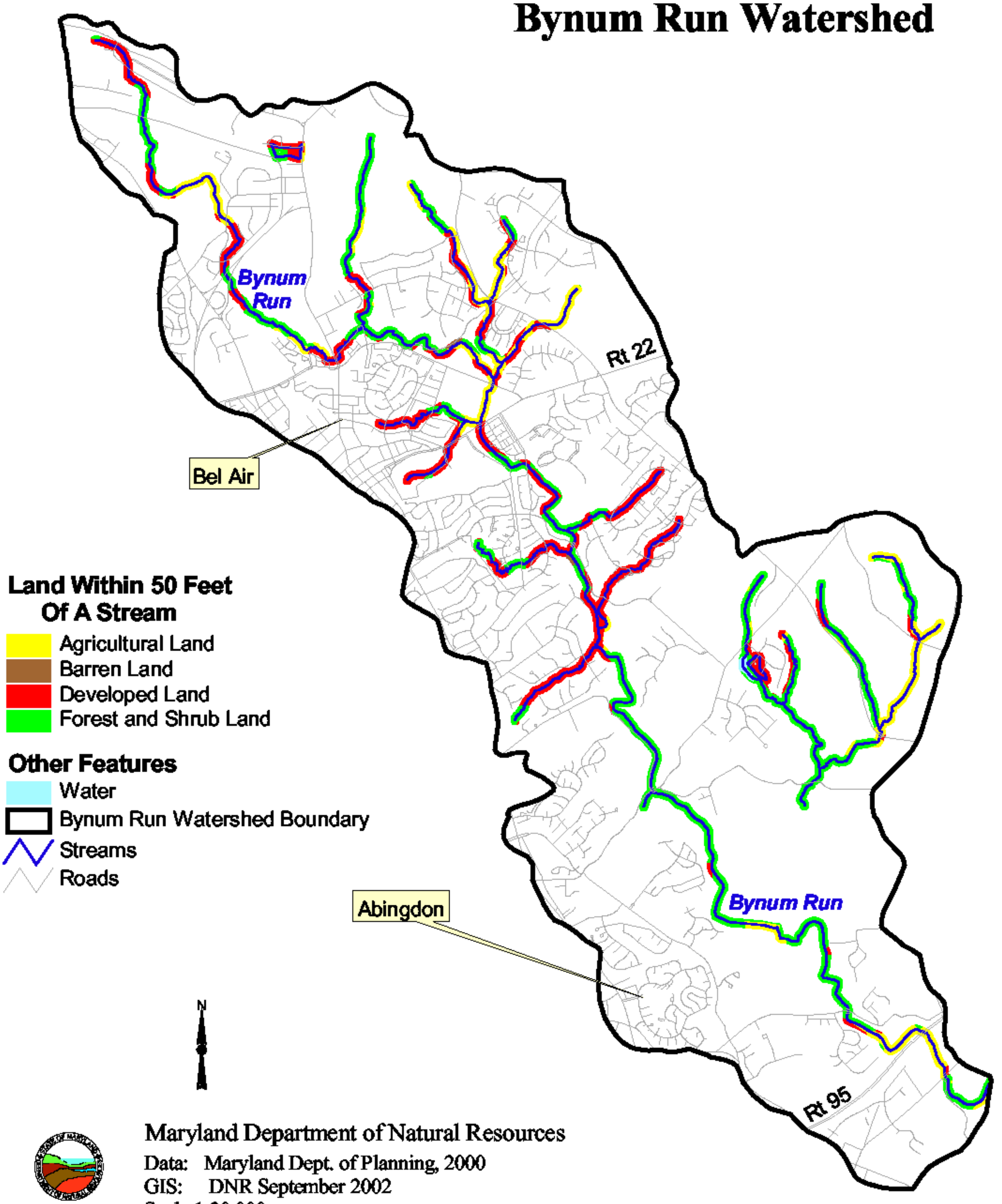
Data: DNR Fish Blockage Database, 2000

GIS: DNR September 2002

Scale 1:150,000

2 0 2 4 Miles

Map 24
Stream Buffer Land Use Scenario
Bynum Run Watershed



Land Within 50 Feet Of A Stream

- Agricultural Land
- Barren Land
- Developed Land
- Forest and Shrub Land

Other Features

- Water
- Bynum Run Watershed Boundary
- Streams
- Roads

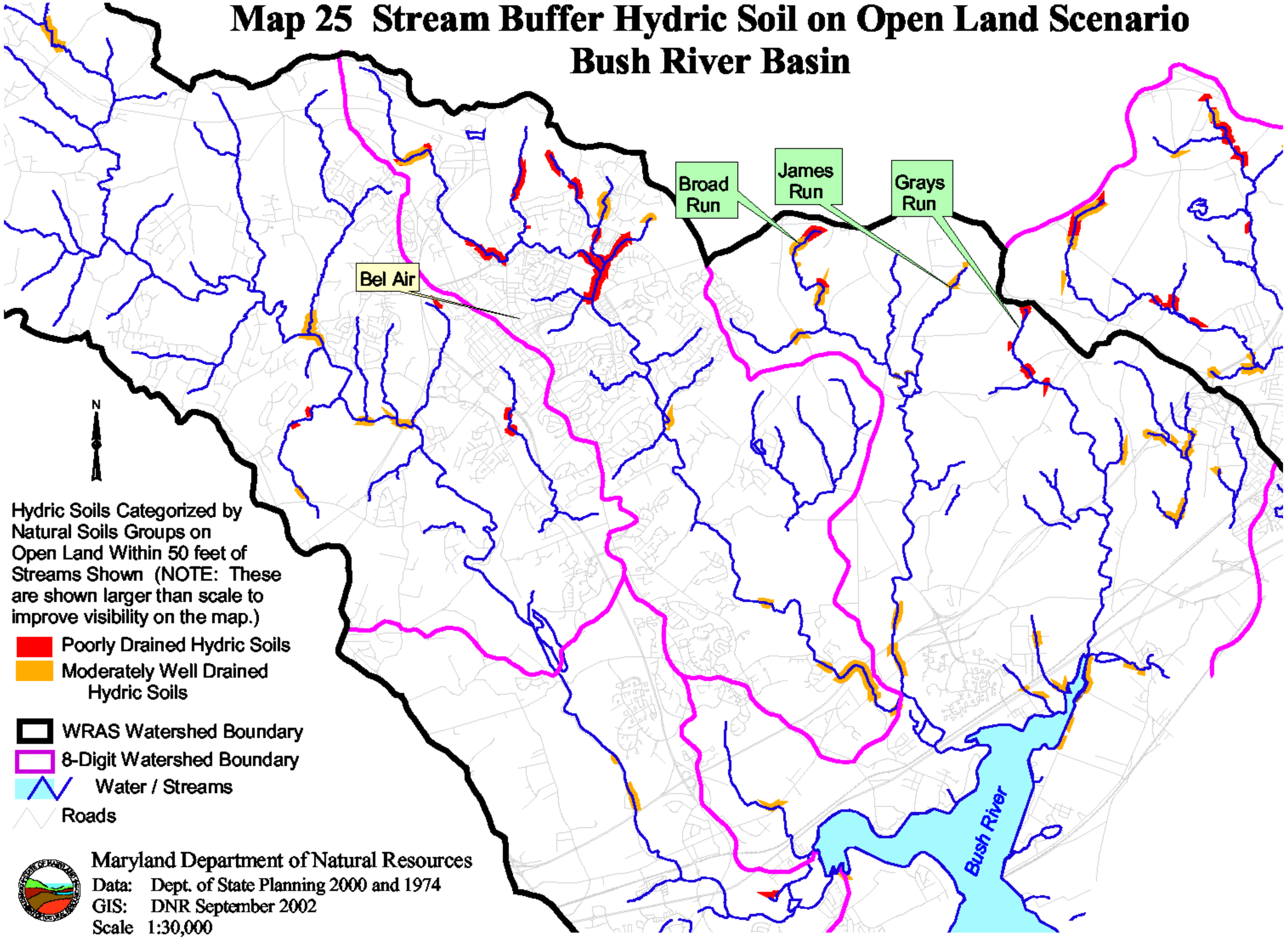
N

Maryland Department of Natural Resources

Data: Maryland Dept. of Planning, 2000
GIS: DNR September 2002
Scale 1:20,000

0.5 0 0.5 1 Miles

Map 25 Stream Buffer Hydric Soil on Open Land Scenario
Bush River Basin



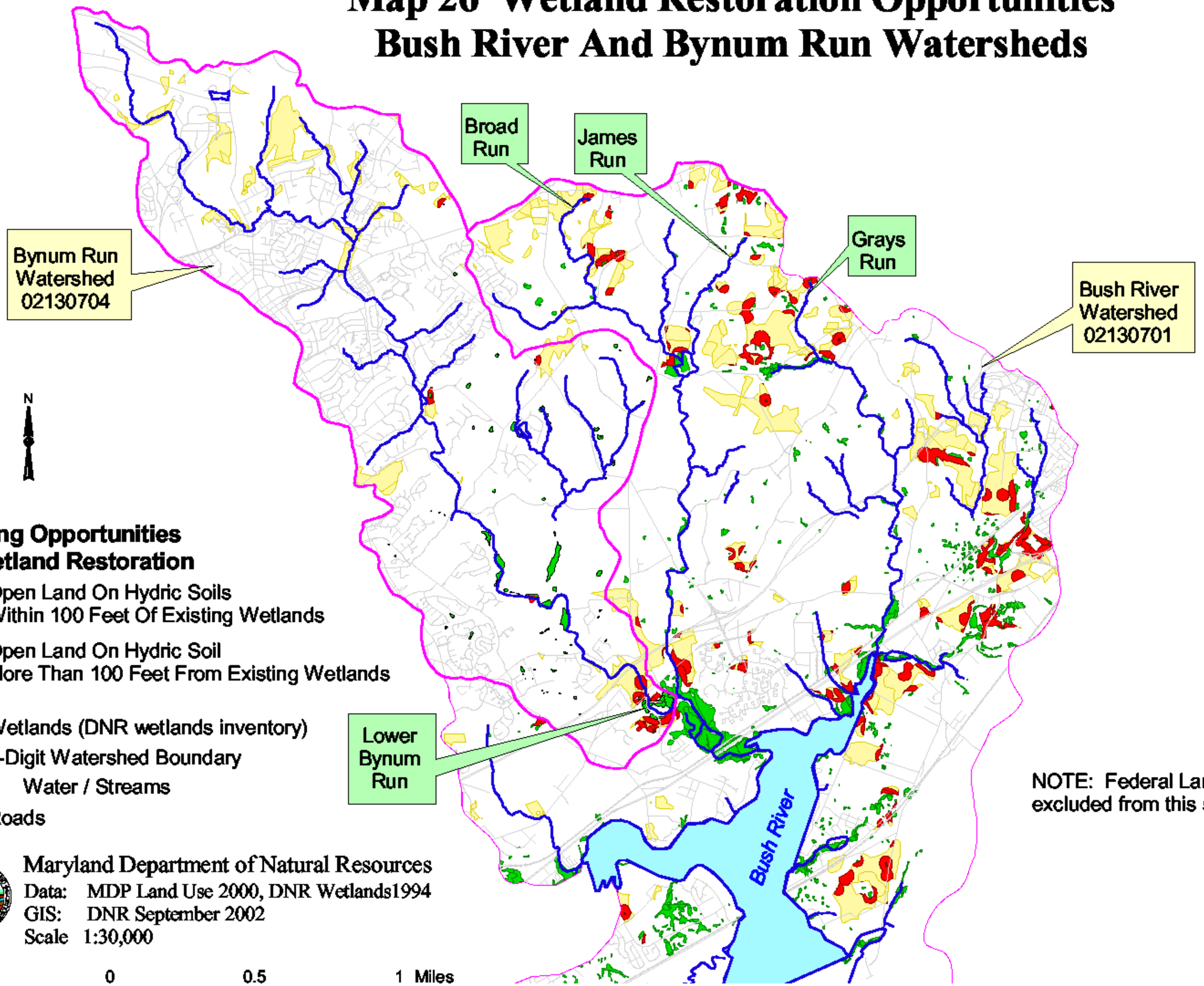
Hydric Soils Categorized by Natural Soils Groups on Open Land Within 50 feet of Streams Shown (NOTE: These are shown larger than scale to improve visibility on the map.)

- Poorly Drained Hydric Soils
- Moderately Well Drained Hydric Soils
- WRAS Watershed Boundary
- 8-Digit Watershed Boundary
- Water / Streams
- Roads

Maryland Department of Natural Resources
Data: Dept. of State Planning 2000 and 1974
GIS: DNR September 2002
Scale 1:30,000

0.5 0 0.5 1 Miles

Map 26 Wetland Restoration Opportunities
Bush River And Bynum Run Watersheds



Ranking Opportunities for Wetland Restoration

- Open Land On Hydric Soils Within 100 Feet Of Existing Wetlands
- Open Land On Hydric Soil More Than 100 Feet From Existing Wetlands
- Wetlands (DNR wetlands inventory)
- 8-Digit Watershed Boundary
- Water / Streams
- Roads

Maryland Department of Natural Resources
Data: MDP Land Use 2000, DNR Wetlands1994
GIS: DNR September 2002
Scale 1:30,000

0.5 0 0.5 1 Miles

NOTE: Federal Land is excluded from this scenario.

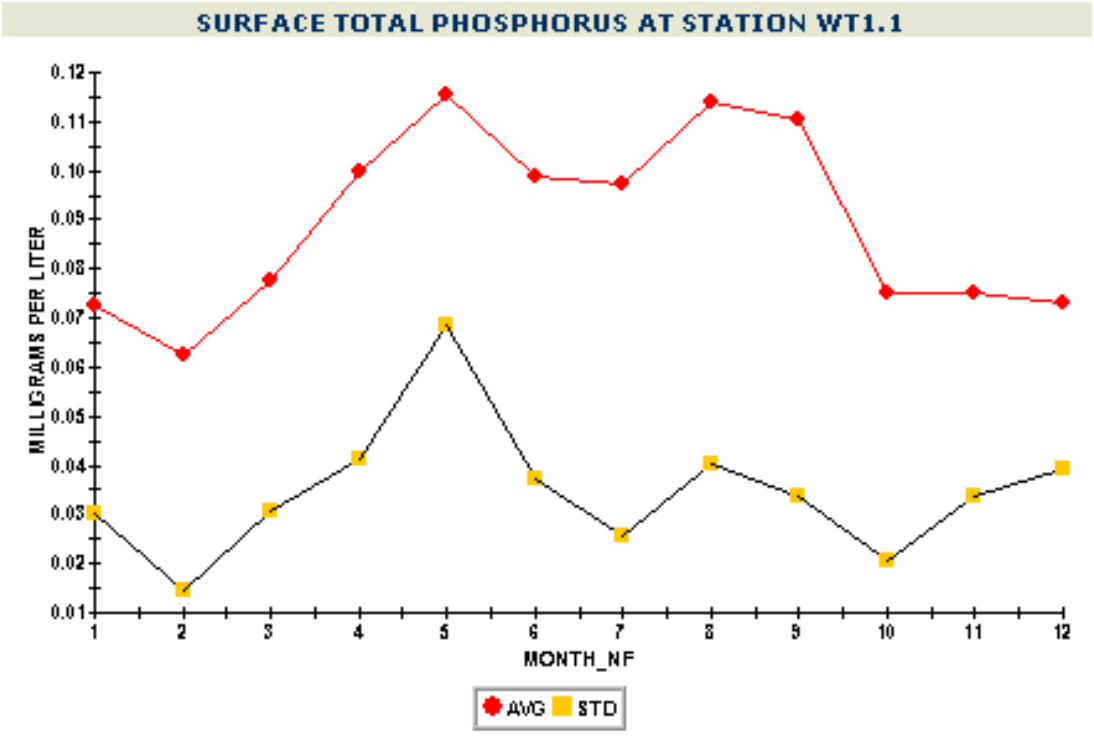
APPENDIX A Selected Water Quality Historic Record for Bush River Station WT1.1

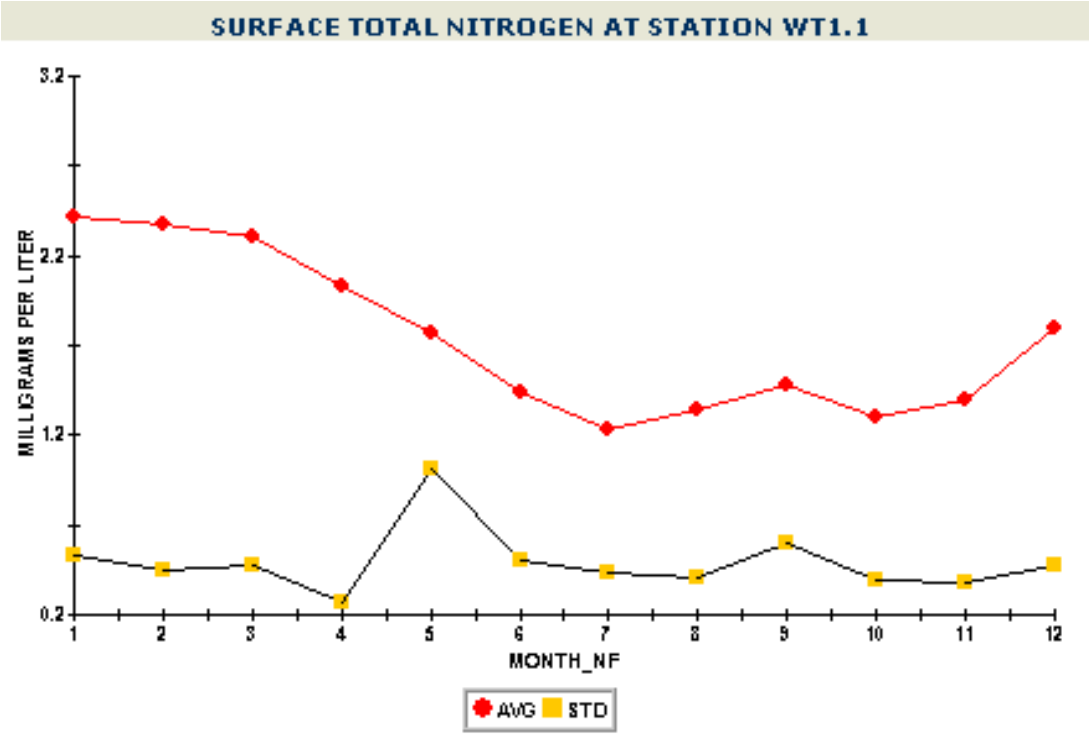
Each graph in this appendix shows how one water quality parameter varies over 12 months based on the historic record for 1985 through 2000. Each graph shows two lines: one showing the average measurment for each month and one showing the standard deviation. The example below suggests how to interpret the graphs.

Abbreviation key for the graphs:
AVG - Average measurement for each month based on the historic record.
STD - Standard Deviation for each month based on the historic record.

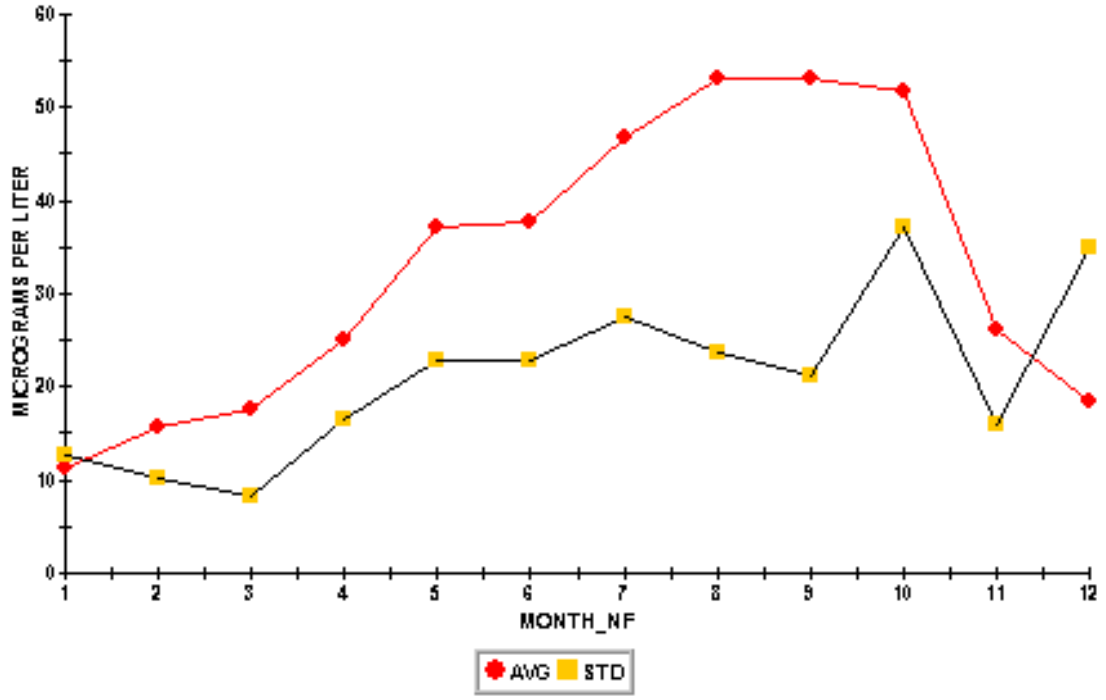
Total Phosphorus (TP) - Interpretation of graph using July as an example.
- The average July TP measurement at Station WT1.1 is slightly less than 0.10 milligrams per liter (mg/l)
- The standard deviation July TP measurement at Station WT1.1 is 0.025 mg/l
- This means that most of time the historic data record shows that total phosphorus at Station WT1.1 in July is between 0.075 mg/l and 0.125 mg/l
- This range for total phosphorous indicates fair water quality.

Total Nitrogen (TN) - Interpretation of graph using July as an example.
- The average July TN measurement at Station WT1.1 is about 1.2 milligrams per liter (mg/l)
- The standard deviation July TN measurement at Station WT1.1 is close to 0.5 mg/l
- This means that most of time the historic data record shows that total phosphorus at Station WT1.1 in July is between 0.7 mg/l and 1.7 mg/l
- This range for total nitrogen indicates fair water quality.

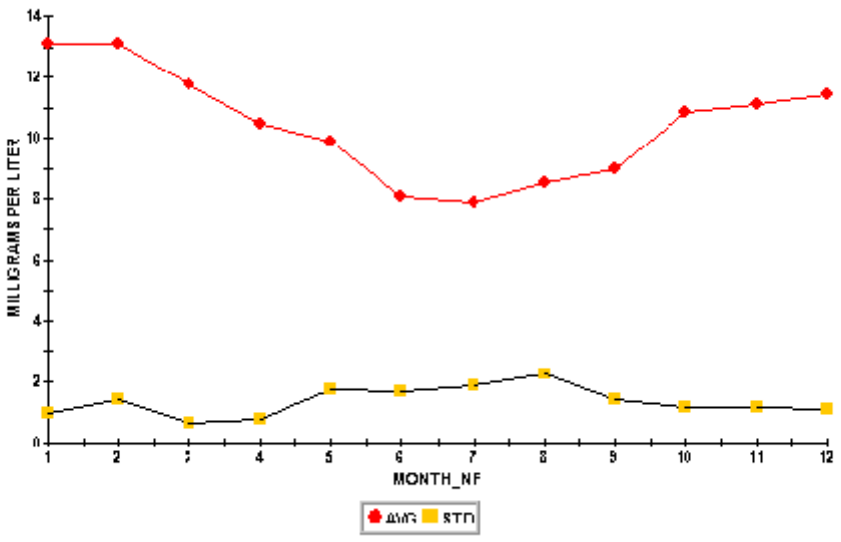

SURFACE TOTAL PHOSPHORUS AT STATION WT1.1
MILLIGRAMS PER LITER
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1 2 3 4 5 6 7 8 9 10 11 12
MONTH_NF
AVG STD


SURFACE TOTAL NITROGEN AT STATION WT1.1
MILLIGRAMS PER LITER
3.2
2.2
1.2
0.2
1 2 3 4 5 6 7 8 9 10 11 12
MONTH_NF
AVG STD

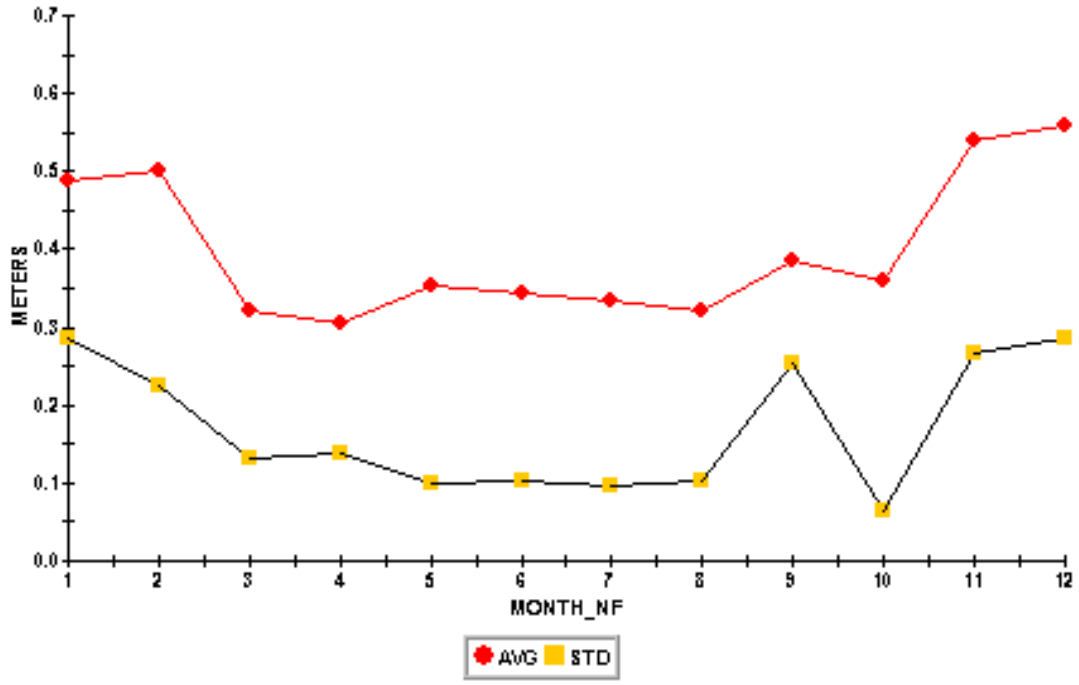
SURFACE ACTIVE CHLOROPHYLL-A AT STATION WT1.1



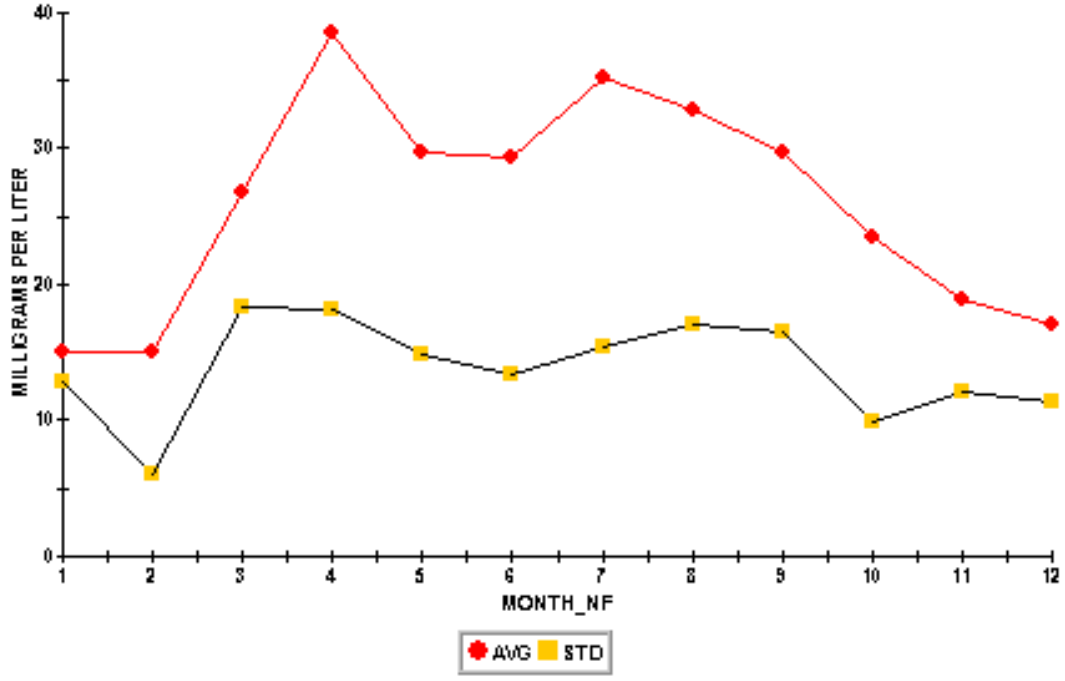
SURFACE DISSOLVED OXYGEN CORRECTED FOR TEMPERATURE (25 DEG C) AND SALINITY AT STATION WT1.1



SURFACE SECCHI DEPTH AT STATION WT1.1



SURFACE TOTAL SUSPENDED SOLIDS AT STATION WT1.1



APPENDIX B Maryland Biological Stream Survey 2000-2004 Volume 1
Ecological Assessment of Watersheds Sampled in 2000

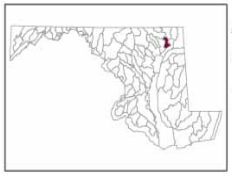
Prepared for
Maryland Department of Natural Resources

Prepared by
Nancy E. Roth, Mark T. Southerland
Ginny Mercurio, Jon H. Volstad

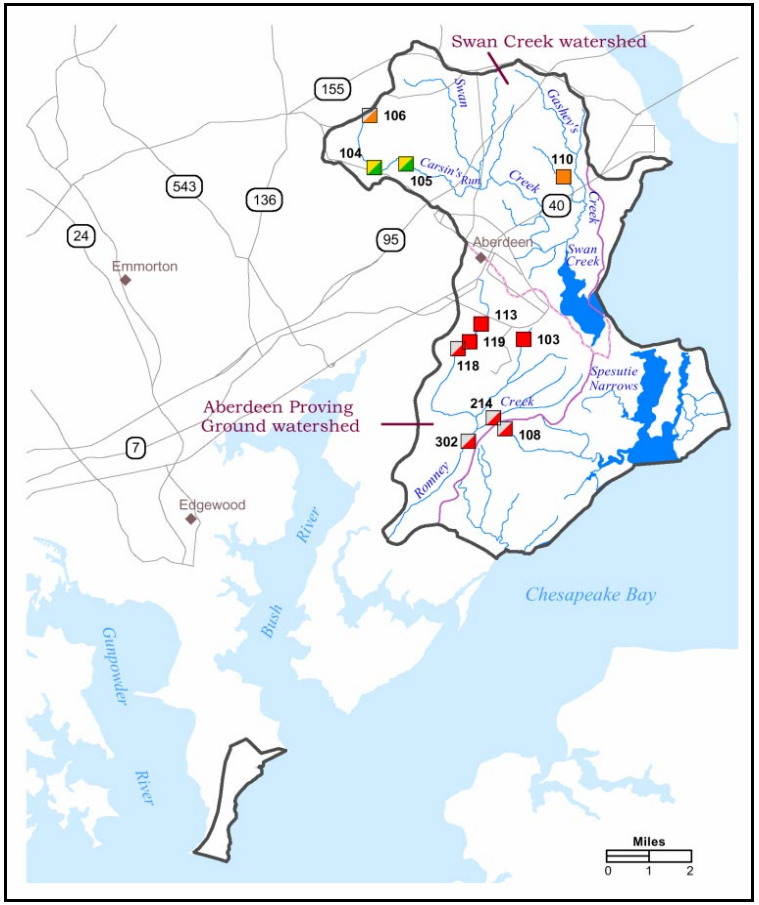
Versar, Inc.
9200 Rumsey Road
Columbia MD 21045

August 2001

Pages extracted from the document for this appendix:

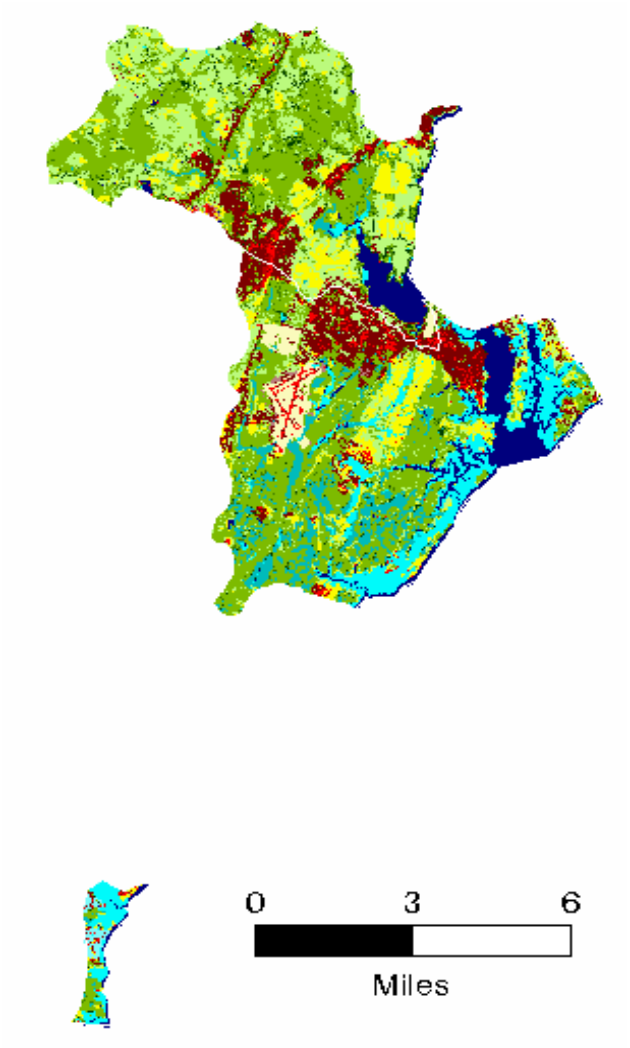


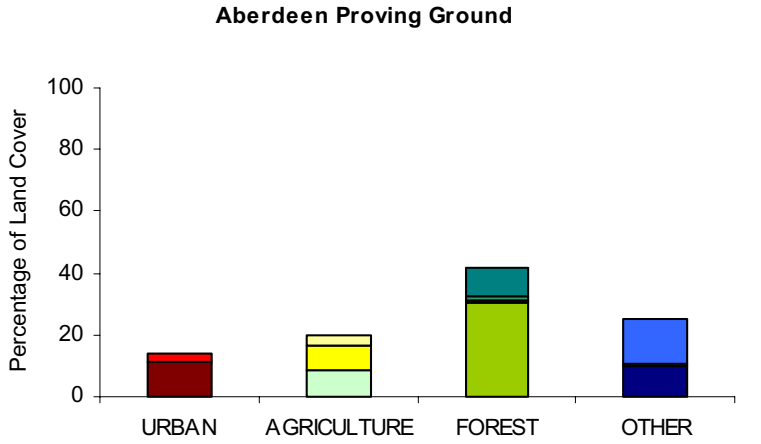
Aberdeen Proving Ground/ Swan Creek watersheds MBSS 2000

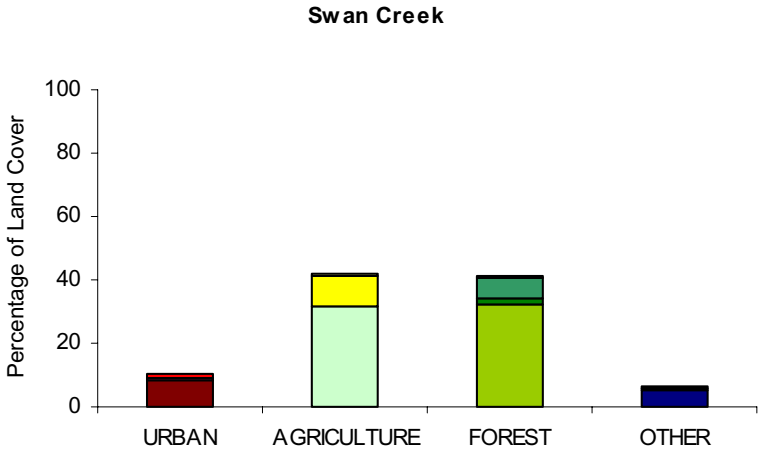


Watershed	Total Land Area (acres)	Total Stream Miles
Aberdeen Proving Ground	21624	26.7
Swan Creek	16862	27.3

Aberdeen Proving Ground/Swan Creek







Aberdeen Proving Ground/Swan Creek

Site Information

Site	Stream Name	12-Digit Watershed Code	8-digit Watershed	Basin	County	Date Sampled Spring	Date Sampled Summer	Order	Catchment Area (acres)
ABPG-103-R-2000	ROMNEY CR UT2	021307051126	Aberdeen Proving Ground	BUSH RIVER	Harford	03/23/00	06/26/00	1	602
ABPG-108-R-2000	MOSQUITO CR	021307051125	Aberdeen Proving Ground	BUSH RIVER	Harford	03/23/00	06/26/00	1	34
ABPG-113-R-2000	ROMNEY CR UT1	021307051126	Aberdeen Proving Ground	BUSH RIVER	Harford	03/23/00	06/27/00	1	1161
ABPG-118-R-2000	ROMNEY CR UT1	021307051126	Aberdeen Proving Ground	BUSH RIVER	Harford	03/23/00	06/26/00	1	1616
ABPG-119-R-2000	ROMNEY CR UT1	021307051126	Aberdeen Proving Ground	BUSH RIVER	Harford	03/23/00	06/26/00	1	1393
ABPG-214-R-2000	ROMNEY CR	021307051126	Aberdeen Proving Ground	BUSH RIVER	Harford	03/21/00	NS	2	1327
ABPG-302-R-2000	ROMNEY CR	021307051126	Aberdeen Proving Ground	BUSH RIVER	Harford	03/21/00	08/21/00	3	7388
SWAN-104-R-2000	CARSINS RUN	021307061135	Swan CR	BUSH RIVER	Harford	03/20/00	06/28/00	1	1049
SWAN-105-R-2000	CARSINS RUN	021307061135	Swan CR	BUSH RIVER	Harford	03/20/00	06/28/00	1	1960
SWAN-106-R-2000	CARSINS RUN	021307061135	Swan CR	BUSH RIVER	Harford	03/20/00	08/21/00	1	252
SWAN-110-R-2000	BLENHEIM RUN	021307061135	Swan CR	BUSH RIVER	Harford	03/20/00	06/27/00	1	507

Indicator Information

Site	FIBI	BIBI	PHI	Brook Trout Present	Black Water Stream
ABPG-103-R-2000	1.00	1.29	48.81	0	0
ABPG-108-R-2000	NR	1.29	5.11	0	1
ABPG-113-R-2000	1.50	1.29	32.03	0	0
ABPG-118-R-2000	NS	1.57	NS	NS	NS
ABPG-119-R-2000	1.00	1.86	2.92	0	0
ABPG-214-R-2000	NS	1.86	NS	NS	NS
ABPG-302-R-2000	3.00	1.29	30.15	0	1
SWAN-104-R-2000	3.67	4.11	37.81	0	0
SWAN-105-R-2000	3.67	4.11	91.59	0	0
SWAN-106-R-2000	NR	2.11	2.80	0	0
SWAN-110-R-2000	2.78	2.78	21.84	0	0

Catchment Land Use Information

Site	Percent Urban	Percent Agriculture	Percent Forest	Percent Other
ABPG-103-R-2000	73.7	17.9	8.1	0.3
ABPG-108-R-2000	0.0	32.4	67.6	0.0
ABPG-113-R-2000	32.3	31.8	35.5	0.5
ABPG-118-R-2000	25.7	36.0	38.0	0.5
ABPG-119-R-2000	26.8	36.7	36.2	0.5
ABPG-214-R-2000	5.0	42.9	40.6	12.6
ABPG-302-R-2000	27.1	31.3	37.4	4.9
SWAN-104-R-2000	0.0	38.9	61.1	0.0
SWAN-105-R-2000	0.1	34.9	64.9	0.3
SWAN-106-R-2000	0.0	51.6	48.4	0.0
SWAN-110-R-2000	0.0	24.3	75.7	0.1

Interpretation of Watershed Condition

Aberdeen Proving Ground

- Extensive urban land use upstream of several sites, although all sampled sites had at least 50 m riparian buffer
- Several sites affected by channelization; several sites (e.g., 113, 118) impacted by a golf course
- Low habitat scores at Site 108 are because very small stream with no flow
- Sites 118 and 119 were impounded upstream of sites; low flow at Site 119 resulted in standing pools during summer sampling
- Beaver dam at Site 214 during spring sampling
- Phosphorous concentrations high at several sites

Swan Creek

- Site 104 had flashy flow, erosion was evident; site receives runoff from repair garage; site on fall line
- Site 106 very small stream with no flow, not severely affected otherwise
- Site 110 in golf course, poor riparian buffer

Aberdeen Proving Ground/Swan Creek

Water Chemistry Information

Site	Closed pH	Specific Cond.	ANC (ueq/L)	Cl (mg/L)	Nitrate-N (mg/L)	SO4 (mg/L)	P-P (mg/L)	TD-P (mg/L)	Ortho-P (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TD-N (mg/L)	P-N (mg/L)	P-C (mg/L)	DOC (mg/L)	DO (mg/L	Turbidity (NTUs)
ABPG-103-R-2000	6.93	196.6	516.5	38.647	0.157	7.829	0.009	0.031	0.012	0.000	0.002	0.620	0.123	1.134	6.026	4.3	12
ABPG-108-R-2000	5.41	49.4	61.5	1.757	0.019	8.964	0.005	0.047	0.015	0.000	0.045	0.598	0.151	1.368	17.905	1.1	14.1
ABPG-113-R-2000	6.76	82.6	353.3	8.281	0.319	5.574	0.016	0.079	0.053	0.000	0.007	0.818	0.158	1.400	7.366	3.2	4.6
ABPG-118-R-2000	6.82	88.6	369.1	9.137	0.450	6.134	0.018	0.073	0.045	0.000	0.000	1.000	0.126	1.247	7.559	NS	NS
ABPG-119-R-2000	6.96	96.3	416.6	10.295	0.346	6.166	0.017	0.073	0.043	0.000	0.000	0.825	0.101	0.953	7.793	16.3	38.1
ABPG-214-R-2000	6.67	102.0	372.8	11.637	0.000	11.031	0.007	0.029	0.002	0.000	0.000	0.621	0.098	0.693	14.252	NS	NS
ABPG-302-R-2000	6.02	161.8	154.1	34.759	0.022	11.411	0.008	0.012	0.003	0.000	0.003	0.560	0.084	0.829	15.965	4.5	55.1
SWAN-104-R-2000	7.39	141.6	616.2	20.214	0.439	6.668	0.001	0.009	0.001	0.000	0.000	0.783	0.025	0.178	6.159	7.4	4.4
SWAN-105-R-2000	7.42	141.3	604.5	18.169	0.582	9.060	0.001	0.008	0.002	0.000	0.000	0.817	0.038	0.241	4.241	6.1	4.2
SWAN-106-R-2000	6.95	116.1	367.0	17.784	0.025	8.212	0.002	0.014	0.001	0.000	0.010	0.462	0.046	0.382	13.743	4.0	51.3
SWAN-110-R-2000	7.44	93.2	392.8	8.622	0.906	8.060	0.002	0.012	0.006	0.000	0.002	1.158	0.122	0.220	2.090	8.1	3.4

Physical Habitat Condition

Site	Riparian Buffer Width Left	Riparian Buffer Width Right	Adjacent Cover Left	Adjacent Cover Right	Instream Habitat Structure	Epifaunal Substrate	Velocity/ Depth Diversity	Pool/Glide/ Eddy Quality	Extent of Pools (m)	Riffle Run Quality	Extent of Riffles (m)	Embedded-ness	Shading	Trash Rating	Maximum Depth (cm)
ABPG-103-R-2000	50	50	PV	FR	12	16	8	7	65	10	20	16	97	14	32
ABPG-108-R-2000	50	50	FR	FR	4	7	2	3	75	2	0	100	95	18	15
ABPG-113-R-2000	50	50	LN	LN	16	16	7	8	75	0	0	100	7	10	32
ABPG-118-R-2000	50	50	FR	FR	NS	NS	NS	NS	NS	NS	NS	NS	NS	17	NS
ABPG-119-R-2000	50	50	FR	FR	2	1	2	2	65	0	0	100	65	15	7
ABPG-214-R-2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
ABPG-302-R-2000	50	50	FR	FR	12	14	3	9	75	0	0	100	72	19	49
SWAN-104-R-2000	25	2	PK	LN	15	11	12	12	60	6	30	5	95	4	93
SWAN-105-R-2000	50	50	HO	PV	15	11	13	13	70	12	10	10	75	10	74
SWAN-106-R-2000	40	10	CP	CP	5	9	2	7	75	0	0	100	98	18	17
SWAN-110-R-2000	50	0	LN	LN	14	18	7	8	30	7	70	25	10	15	24

Physical Habitat Modifications

Site	Buffer Breaks?	Surface Mine?	Landfill?	Channelization?	Erosion Severity Left	Erosion Severity Right	Bar Formation
ABPG-103-R-2000	N	N	Y	Y	Moderate	Severe	Moderate
ABPG-108-R-2000	N	N	N	Y	None	None	None
ABPG-113-R-2000	N	N	N	Y	None	None	None
ABPG-118-R-2000	N	N	N	Y	NS	NS	NS
ABPG-119-R-2000	N	N	N	Y	None	None	Minor
ABPG-214-R-2000	N	N	N	N	NS	NS	NS
ABPG-302-R-2000	N	N	N	N	Mild	Mild	None
SWAN-104-R-2000	Y	N	N	N	None	Severe	Severe
SWAN-105-R-2000	N	N	N	Y	Mild	Mild	Moderate
SWAN-106-R-2000	N	N	N	N	Moderate	Mild	None

SWAN-110-R-2000	N	N	N	N	Mild	None	Minor

Aberdeen Proving Ground/ Swan Creek

Fish Species Present

AMERICAN EEL
BANDED SUNFISH
BLACKNOSE DACE
BLUEGILL
BROWN BULLHEAD
COMMON SHINER
CR CHUB
CR CHUBSUCKER
CUTLIPS MINNOW
EASTERN MUDMINNOW
GOLDEN SHINER
GOLDFISH
GREEN SUNFISH
LARGEMOUTH BASS
MUMMICHOG
PUMPKINSEED
REDBREAST SUNFISH
REDFIN PICKEREL
ROSYSIDE DACE
SWALLOWTAIL SHINER
TADPOLE MADTOM
TESSELLATED DARTER
WHITE SUCKER
YELLOW BULLHEAD

Exotic Plants Present

JAPANESE HONEYSUCKLE
MICROSTEGIUM
MULTIFLORA ROSE
THISTLE

Benthic Taxa Present

ABLABESMYIA
ACENTRELLA
ACRONEURIA
AGABETES
AGABUS
AMELETUS
AMPHINEMURA
BAETIDAE
BEROSUS
BEZZIA
BRILLIA
CERATOPOGONIDAE
CHIRONOMINI
CRANGONYCTIDAE
CAECIDOTEA
CHEUMATOPSYCHE
CLINOCERA
CONCHAPELOPIA
CRANGONYX
CRICOTOPUS
CRICOTOPUS/ORTHOCLADIUS
DYTISCIDAE
DIAMESA
DICROTENDIPES
DIPLECTRONA
ENCHYTRAEIDAE
ENALLAGMA
EPEORUS
EPHEMERELLA
EUKIEFFERIELLA
EURYLOPHELLA
GOMPHIDAE
GORDIIDAE
GLYPTOTENDIPES
GYRAULUS
HELOPHORUS
HEXATOMA
HYDROPORUS
KIEFFERULUS
LUMBRICULIDAE
LIMONIA
MENETUS
NAIDIDAE
NEMOURIDAE
NEOPHYLAX
NIGRONIA
ORTHOCLADIINAE
OPTIOSERVUS
ORMOSIA
ORTHOCLADIINAE A
ORTHOCLADIUS
PERLIDAE
PERLODIDAE
PARALEPTOPHLEBIA
PARAMETRIOCNEMUS
PARAPHAENOCLADIUS
PARATANYTARSUS
PHYSELLA
PISIDIUM
POLYPEDILUM
PROCLADIUS
PROSIMULIUM
PROSTOIA
PSEPHENUS
PSEUDOSUCCINEA
RHEOCRICOTOPUS
RHEOTANYTARSUS
RHYACOPHILA
SIMULIIDAE
SPHAERIIDAE
SIMULIUM
SMITTIA
SPHAERIUM
STAGNICOLA
STEGOPTERNA
STENELMIS
STILOBEZZIA
SYMPOSIOCLADIUS
SYMPOTTHASTIA
TUBIFICIDAE
TABANUS
TANYTARSUS
THIENEMANNIELLA
TRIAENODES
WORMALDIA

Herpetofauna Present

BLACK RAT SNAKE
BULLFROG
COMMON SNAPPING TURTLE
EASTERN BOX TURTLE
FOWLER'S TOAD
GREEN FROG
NORTHERN TWO-LINED SALAMANDER
NORTHERN WATER SNAKE
PICKEREL FROG
SOUTHERN LEOPARD FROG

Table 4-1. Key to PSU reports for PSUs sampled in the 2000 MBSS

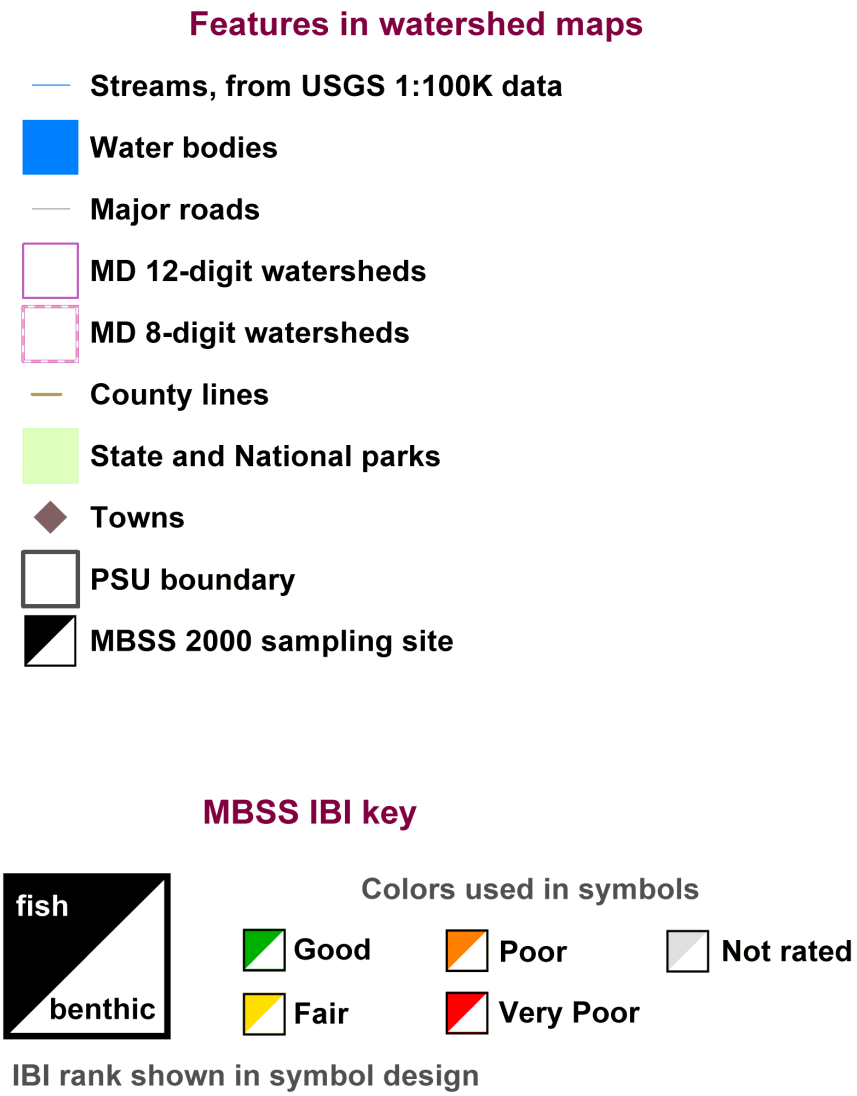


Table 4-1. (Continued)

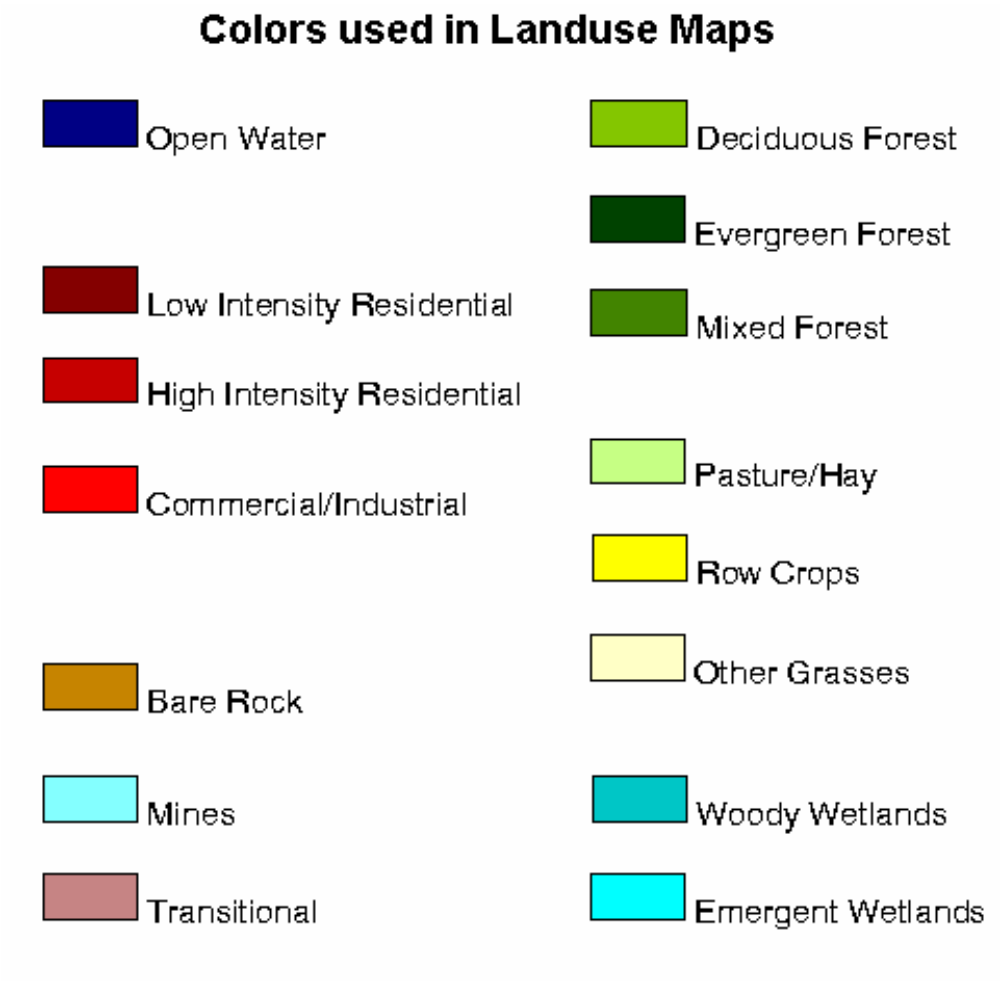


Table 4-1. (Continued)

Guide to Variables in PSU Reports

Site Information

Site: MBSS site name, in the following format: Watershed Abbreviation - Segment Number - Site Type - Year Sampled (Site Type R = Randomly selected site)

Stream Name: Name of stream sampled

12-digit Watershed Code: Maryland 12-digit watershed code

8-digit Watershed: Maryland 8-digit watershed name

Basin: Maryland drainage basin name

County: Maryland county

Date Sampled Spring: Date site was sampled in the spring

Date Sampled Summer: Date site was sampled in the summer (NS = Not Sampled)

Order: Strahler stream order

Catchment Area: Area of upstream catchment in acres

Indicator Information

FIBI: Fish Index of Biotic Integrity, scored on the following scale:

1.0 - 1.9 Very Poor
2.0 - 2.9 Poor
3.0 - 3.9 Fair
4.0 - 5.0 Good
NS Not Sampled
NR Not Rated (site is not rated if catchment area is < 300 acres, or if the site is a brook trout or blackwater stream and would have received a score of less than 3.0)
Site is shaded if IBI score is < 3.0

BIBI: Benthic Index of Biotic Integrity, scored on the following scale:

1.0 - 1.9 Very Poor
2.0 - 2.9 Poor
3.0 - 3.9 Fair
4.0 - 5.0 Good
NS Not Sampled
NR Not Rated
Site is shaded if IBI score is < 3.0

Table 4-1. (Continued)

PHI: Physical Habitat Index, scored on the following scale:
- 0 - 11.9 Very Poor
- 12 - 41.9 Poor
- 42 - 71.9 Fair
- 72 - 100 Good
- NS Not Sampled
- NR Not Rated
- Site is shaded if PHI score is < 42

Brook Trout Present: 0 = Not present in sample segment, 1 = Present in sample segment, NS = Not Sampled

Black Water Stream: 0 = Not a blackwater stream, 1 = Blackwater stream (pH < 5 or ANC < 200 µeq/L and Dissolved Organic Carbon ≥ 8 mg/L), NS = Not Sampled

Catchment Land Use Information

Percent Urban: Percentage of urban land use in catchment upstream of site. Site is shaded if value is ≥ 25%.

Percent Agriculture: Percentage of agricultural land use in catchment upstream of site. Site is shaded if values is ≥ 75%.

Percent Forest: Percentage of forested land use in catchment upstream of site

Percent Other: Percentage of other land use in catchment upstream of site (other = wetlands, barren, and water)

Water Chemistry Information

Closed pH: Lab pH, sampled in the spring. Site is shaded if value is < 5.0.

Specific Cond.: Specific Conductivity (μmho/cm)

ANC: Acid Neutralizing Capacity (μeq/L). Site is shaded if value is < 200 ueq/L.

Cl: Chloride (mg/L). Site is shaded if value is ≥ 30 mg/L.

Nitrate-N: Nitrate Nitrogen (mg/L). Site is shaded if value is ≥ 1.0 mg/L

SO4: Sulfate (mg/L). Site is shaded if value is ≥ 50 mg/L.

P-P: Particulate Phosphorus (mg/L). Site is shaded if value is ≥ 0.005 mg/L.

TD-P: Total Dissolved Phosphorus (mg/L). Site is shaded if value is ≥ 0.0175 mg/L.

Ortho-P: Orthophosphate (mg/L). Site is shaded if value is ≥ 0.005 mg/L.

Nitrite: Nitrite Nitrogen (mg/L). Site is shaded if value is ≥ 0.0075 mg/L.

Ammonia: Ammonia (mg/L). Site is shaded if value is ≥ 0.025 mg/L.

TD-N: Total Dissolved Nitrogen (mg/L). Site is shaded if value is ≥ 2.0 mg/L.

P-N: Particulate Nitrogen (mg/L). Site is shaded if value is ≥ 0.05 mg/L.

P-C: Particulate Carbon (mg/L)

DOC: Dissolved Organic Carbon (mg/L). Site is shaded if value is ≥ 8.0 mg/L.

DO: Dissolved Oxygen (mg/L). Site is shaded if value is ≤ 5 mg/L.

Turbidity: Turbidity (NTUs). Site is shaded if value is ≥ 10 NTUs.

Table 4-1. (Continued)

Physical Habitat Condition

Riparian Buffer Width Left: Width of the riparian buffer on the left bank (meters). Site is shaded if value is < 10 m.

Riparian Buffer Width Right: Width of the riparian buffer on the right bank (meters). Site is shaded if value is < 10 m.

Adjacent Cover Left: Type of adjacent land cover on the left bank

Adjacent Cover Right: Type of adjacent land cover on the right bank

The following variables are scored on the following scale:

0-5 Poor
6-10 Marginal
11-15 Sub-optimal
16-20 Optimal
Sites are shaded if scores are ≤ 6.

Instream Habitat Structure: Scored based on the value of instream habitat to the fish community

Epifaunal Substrate: Scored based on the amount and variety of hard, stable substrates used by benthic macroinvertebrates

Velocity/Depth Diversity: Scored based on the variety of velocity/depth regimes present at a site

Pool/Glide/Eddy Quality: Scored based on the variety and complexity of slow or still water habitat present at a site

Riffle Run Quality: Scored based on the depth, complexity, and functionality of riffle/run habitat present at a site

Extent of Pools: The extent of pools, glides, and eddys present at a site (meters). Site is shaded if value is 0 m.

Extent of Riffles: The extent of riffles and runs present at a site (meters). Site is shaded if value is 0 m.

Embeddedness: Scored as a percentage (0-100) based on the fraction of surface area of larger particles surrounded by finer sediments. Site is shaded if value is 100%.

Shading: Scored as a percentage (0-100) based on estimates of the degree and duration of shading of sites during the summer. Site is shaded if value is 0%.

Trash Rating: Scored base on the visual appeal of the site and the presence/absence of human refuse. Site is shaded if value is ≤ 6.

Maximum Depth: Maximum depth of the stream (centimeters). Site is shaded if value is ≤ 20 cm.

Physical Habitat Modifications

Buffer Breaks?: Presence/absence of breaks in the riparian buffer, either right or left bank (Y/N). Site is shaded if value is Y.

Surface Mine?: Surface Mine present at the site (Y/N). Site is shaded if value is Y.

Landfill?: Landfill present at the site (Y/N). Site is shaded if value is Y.

Channelization: Stream channelization evident at the site (Y/N). Site is shaded if value is Y.

Erosion Severity Left - Severity of erosion on left bank (Severe, Moderate, Mild, or None). Site is shaded if value is Severe.

Erosion Severity Right - Severity of erosion on right bank. Site is shaded if value is Severe.

Bar Formation - Extent of bar formation in stream (Severe, Moderate, Mild, or None). Site is shaded if value is Severe

Table 4-1. (Continued)

Watershed Abbreviations

ABPG	Aberdeen Proving Grounds
BRIG	Brighton Dam
CASS	Casselman River
CORS	Corsica River
FIMI	Fifteen Mile Creek
LIBE	Liberty Reservoir
LOWI	Lower Wicomico Creek
LPAX	Little Patuxent River
LTON	Little Tonoloway
MARS	Marsh Run
MATT	Mattawoman Creek
MONI	Monie Bay
NANJ	Nanjemoy Creek
PRET	Prettyboy Reservoir
PRWA	Potomac River Washington County
SBPA	South Branch Patapsco River
SEAS	Southeast Creek
STMA	St. Mary's River
SWAN	Swan Creek
TOWN	Town Creek
UMON	Upper Monocacy
UPCK	Upper Choptank
WIRH	Wicomico River Head

Cover Type Abbreviations

CP	Cropland
DI	Dirt Road
EM	Emergent Vegetation
FR	Forest
GR	Gravel Road
HO	Housing
LN	Mowed Lawn
LO	Logged Area
OF	Old Field
OR	Orchard
PA	Pasture
PK	Parking Lot/Industrial/Commercial
PV	Paved Road
RR	Railroad
SL	Bare Soil
TG	Tall Grass