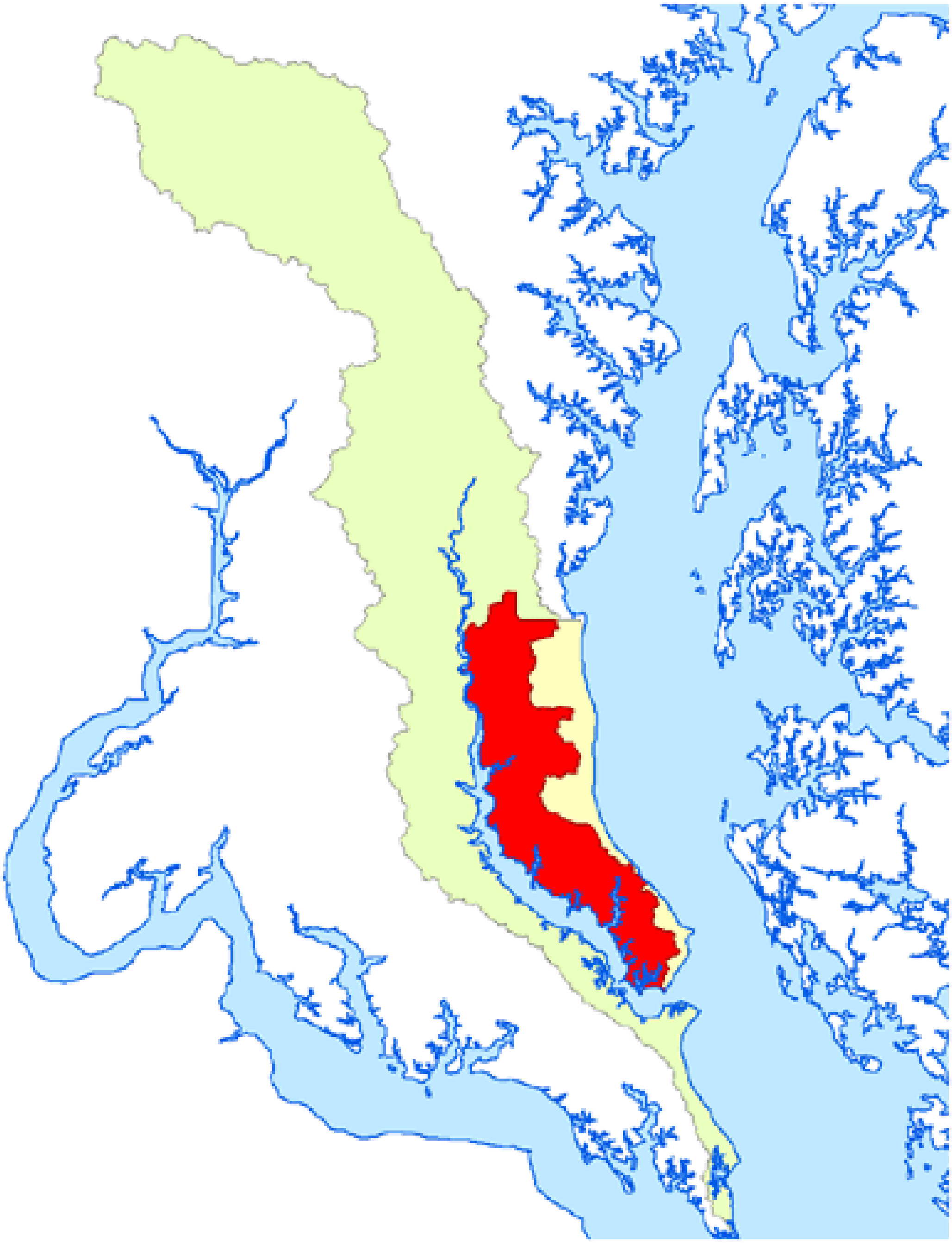
Lower Patuxent River In Calvert County Watershed Characterization

December 2003



In support of Calvert County's
Watershed Restoration Action Strategy
for the Lower Patuxent Watershed

Product of the Maryland Department of Natural Resources
Watershed Services in Partnership with Calvert County

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Lower Patuxent River Watershed Characterization
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EXECUTIVE SUMMARY
For the Lower Patuxent Watershed Characterization

Calvert County, Maryland is receiving Federal grant funding to prepare a Watershed Restoration Action Strategy (WRAS) for the Lower Patuxent Watershed. The WRAS project area encompasses over 152 square miles (97,647 acres) of land in Calvert County. This is nearly 47% of the land area in the Lower Patuxent River watershed.

As part of WRAS project, the Maryland Department of Natural Resources (DNR) is providing technical assistance, including preparation of a watershed characterization (compilation of available water quality and natural resources information and identification of issues), a stream corridor assessment (uses field data to catalog issues and rate severity) and a synoptic survey (analyzes benthic macroinvertebrates, fish and water samples with focus on nutrients). The County may use information generated in these efforts as it drafts the County Watershed Restoration Action Strategy.

Water Quality

In the Lower Patuxent River, impairments to tidal water quality in the mainstem arise from inputs originating from both inside and outside of the WRAS project area. Total nitrogen and total phosphorus concentrations in the mainstem have tended to improve (lower concentrations) from 1985 through 2001. However, algae blooms in the tidal mainstem (over 100 micrograms per liter of chlorophyll *a*) continue to be supported by excess nutrient availability. Suspended solids contribute to water quality impairment from below Route 231 to the upstream boundary of the WRAS project area.

In the WRAS project area, nutrient loads are dominated by nonpoint sources including septic systems, fertilizer use and atmospheric deposition. Nonpoint source nitrogen from septic systems appears to be a significant contributor to local tidal water quality impairment, particularly in tidal inlets like the Solomons Harbor area.

Several tidal inlets along the Patuxent River in Calvert County are impaired by fecal coliform bacteria, including: Battle Creek, Buzzard Island Creek, Island Creek, Mill Creek and Solomons Island Harbor.

Methylmercury contamination found in fish caught in Lake Lariat caused this freshwater impoundment to be listed on the State's list of impaired water bodies. Mercury reaching the lake is mostly associated with atmospheric deposition. To help address this impairment, a draft TMDL is in review by US EPA.

Some nontidal streams exhibit biological limitations that are the result of local conditions.

Several parts of the Patuxent River mainstem are identified as an Area of Emphasis due to levels of toxic compounds found there. In the upper tidal Patuxent River, upstream of Chaulk Point, pesticides found in the water (chlorpyrifos and malathion) and in sediment (DDT) were at levels indicating probable adverse effects on living resources. In the middle tidal Patuxent River, between Chaulk Point and Sheridan Point (midway between Battle Creek and Rt. 231), levels of the pesticide chlorpyrifos in the water and in the sediment were high enough to indicate probable adverse effects on living resources. In the lower portion of this segment, metals and the pesticide DDT levels were high enough to potentially cause adverse effects to living resources. Both water and sediment from this area caused adverse effects on Bay organisms under laboratory conditions.

Groundwater is the source for all community water supply systems in Calvert County. These systems all pump from confined aquifers: the Aquia and the Piney Point-Nanjemoy. Both aquifers have deepening cones of depression where withdrawals are highest like the Solomons Island vicinity. Modeling of anticipated future use rates indicate that dropping water levels in these aquifers could reach State permitting limits by 2025 unless some withdrawals are shifted to a deeper aquifer.

The Landscape

Forest accounts for nearly 49% of the land use / land cover in the Calvert County portion of the Lower Patuxent River watershed based on Year 2000 data. Both agricultural and developed land each cover nearly almost one quarter of this area.

Impervious area averages for subwatersheds across the project area typically are less than two percent. Greater impervious cover is found in only one area – the Solomons Harbor subwatershed has 2.9% impervious cover on average.

Green Infrastructure hubs, large natural habitat areas of statewide significance, are concentrated in subwatersheds of several creeks (Hall, Hunting, St. Leonards, Battle, Helen and St. John) and at Kings Landing. Only four of these hubs have any protection from land use conversion. Blocks of forest interior are found in all subwatersheds and are generally not protected.

Agricultural easements account for 43% of all protected land in the WRAS project area and cover about as much land as County parks and DNR land combined.

Living Resources and Habitat

Significant spawning areas for anadromous fish are documented in three creeks: Hall, Hunting and Lyons. Additional spawning areas are St. Leonards, Helen and Mill Creeks. Hunting Creek has the most diverse fish population of nontidal streams segments that have been surveyed.

Algae blooms of green and bluegreen algae that are associated with excessive nutrients loads are common in the mainstem of the Patuxent River. Both mahogany tides and black tides occurred in the mainstem and both St. Leonards Creek and Battle Creek experienced black tides. The causes of these blooms are not well understood.

Maryland Biological Stream Survey has assessed six stream segments in the WRAS area. Ratings for these sites were mostly poor or fair but several ratings of very poor were found.

Oyster harvests from the Patuxent River are currently a tiny fraction of historic harvests. Legally delineated oyster bed areas in the Patuxent River mainstem encompass over 10,000 acres. Ninety years ago, natural oyster beds were reported to cover 5,661 acres.

Ecological sensitive areas that contain species tracked by Maryland as endangered or threatened are identified in about 20 separate parts of the WRAS area. The two largest are at

Battle Creek and the vicinity of Kings Landing and Lower Marlboro around Chew Creek, Tyverne Creek and Graham Creek.

Submerged aquatic vegetation (SAV) covers relatively little area of the Lower Patuxent River in recent years compared to the earlier part of this century. In the mid 1980s and late 1990s, SAV beds have covered up to about 100 areas. However, no SAV could be identified in aerial photographs in the early 1990s. In research slated to be published in late 2003, the relationship between Patuxent nutrient loads and the extent of submerged aquatic vegetation (SAV) is to be explored. The research is anticipated to qualitatively show that decreasing SAV area coincides with increasing nutrient loads. However, as nutrient loads decreased, Patuxent SAV have not shown a similar rebound.

Restoration Targeting Tools

Using GIS, potential opportunities for stream buffer restoration and wetland restoration have been identified. Based on this GIS assessment, most subwatersheds in the WRAS area have locations that could be investigated as potential restoration opportunities. These GIS scenarios are intended to supplement the field information being collected during 2003 in the Stream Corridor Assessment which catalogs and rates conditions found along and in streams. Additionally, the Synoptic Survey being conducted in 2003 will contribute water quality data, including nutrients, and assessment of fish and benthic communities at selected sampling sites.

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INTRODUCTION

Background

In 1998, Maryland completed an assessment of all 134 of the state's watersheds in order to identify high priorities for restoration action based on impaired waters and high priorities for conservation action based on high or unique natural resource value. The assessment, called the Unified Watershed Assessment, was conducted by the Maryland Department of Natural Resources (DNR) under the direction of the US Environmental Protection Agency's Clean Water Action Plan initiative with assistance from the Maryland Departments of Environment, Agriculture and Planning and the University of Maryland. It moved beyond consideration of water quality in the streams in the state, which had been assessed regularly since the early 1970's, to a larger consideration of living resources in the streams and the landscape conditions which could impact both water quality and living resources.[1,2]

In response to the findings of the Unified Watershed Assessment, DNR offers technical and financial assistance to local governments who are willing to develop and implement Watershed Restoration Action Strategies (WRAS) addressing needs for restoration and conservation in priority watersheds. One of these projects is the Lower Patuxent River Watershed in Calvert County, where the County, DNR and other local cooperators, both public and private, are engaged in developing a watershed management strategy.

Location

Map 1 Location shows that the Lower Patuxent Watershed is located within the Patuxent River basin. The map and adjacent table show that the watershed is shared by five Counties. The WRAS project area is entirely in Calvert County encompassing 47% of the entire watershed. Map 2 WRAS Project Area This area is the focus of the Watershed Restoration Action Strategy and this Watershed Characterization. Also shown in Map 2 and the table Subwatersheds, the State of Maryland subdivides the Lower Patuxent Watershed into twelve subwatersheds for analytical purposes.

Lower Patuxent In Calvert County
Watershed Acreage Summary
MDP 2000 Land Use/Land Cover

County	Land	Water	Total	Percent
Calvert	**97,647**	**13,549**	**111,196**	**47**
Anne Arundel	3,289	0	3,289	1
Charles	17,942	1,209	19,151	8
Prince George's	31,134	1,970	33,104	14
St. Mary's	59,264	13,719	72,983	30
Total	209,276	47,531	239,722	100

Purpose of the Characterization

One of the earliest steps in 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.
– provide a common base of knowledge about the Lower Patuxent Watershed for local governments, citizens, businesses and other organizations

Additional Characterization Work

The Watershed Characterization is intended to be one starting point that can be updated as needed. It is part of a framework for a more thorough assessment with additional inputs:

– self-investigation by Calvert County
– targeted technical assistance and assessment by partner agencies or contractors
– input from local citizens
– completion of a Stream Corridor Assessment, in which DNR personnel physically walk the streams and catalogue important issues.
– completion of a synoptic water quality survey, i.e. a program of water sample analysis, that can be used to focus on local issues like nutrient hot spots, point source discharges or other selected issues.

Identifying Gaps in Information

It is important to identify gaps in available watershed knowledge and gauge the importance of these gaps. In assessing data gaps, we have found it helpful to review information in four categories:

– Habitat: physical structure, stream stability and biotic community (incl. riparian zone)
– Water Quantity: high water–storm flow and 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.

Because restoration is an active evolving process, the Watershed Characterization and the resulting Watershed Restoration Action Strategy should be maintained as living documents within an active evolving restoration process. These documents will need to be updated periodically as new, more relevant information becomes available and as the watershed response is monitored and reassessed.

Subwatersheds Lower Patuxent Watershed / WRAS Project Area			
Name	Number 02131101-XXXX	Area in Acres including Water	Selected Stream Information Within The Watershed
Hall Creek	0902	10,488	Calvert County portion only
Graham & Fridays Creeks	0900	3,947	
Chew Creek	0899	4,960	includes Tyverne Creek
Cocktown Creek	0896	4,934	
Deep Landing	0895	3,339	streams are unnamed
Hunting Creek	0889	20,382	includes Little Lyons Creek
Ramsey & Caney Creeks	0888	3,869	
Buzzard Island Creek	0882	6,239	
Battle Creek Headwaters	0881	6,521	
Battle Creek Lower Drainage	0879	5,971	
Island Creek	0878	8,341	includes Nan Cove, Rock Creek, Ben Creek and Jack Bay
St. Leonard Creek	0876	22,792	includes Hellen Creek, Mears Creek
Solomons Harbor	0873	9,413	includes Hungerford Creek
Lower Patuxent Watershed Totals 02131101		111,196 3,289 114,485	Calvert County Anne Arundel County (Hall Creek) Calvert and Anne Arundel Counties

WATER QUALITY

Water quality is in many respects the driving condition in the health of Maryland's streams. Historically, efforts to protect water quality have focused on chemical water quality. More recently, additional factors are being considered like measurements of selected biological conditions and physical conditions that affect habitat quality in streams and estuaries. This developmental path is reflected in the ways in which streams have been monitored, the types of data gathered, and the regulatory approach taken.

Water Quality Standards and Designated Uses

All streams and other water bodies in Maryland are assigned a "designated use" in the Code of Maryland Regulation (COMAR) 26.08.02.08, which is associated with a set of water quality criteria necessary to support that use. The Lower Patuxent Watershed is assigned two uses:

- Use I, Water Contact Recreation and Protection of Aquatic Life: All surface waters not designated as Use II.

- Use II, Shellfish Harvesting Waters: All estuarine areas of tributaries except Patuxent River and tributaries above Ferry Landing

Map 3 Designated Uses and Use Restrictions depicts the distribution of surface waters in each category. (COMAR or MDE should be consulted for official regulatory information.) [3,5]

Use Impairments and Restrictions[4]

Some streams or other water bodies in the WRAS project area can not be used to the full extent envisioned by their designated use in Maryland regulation due to water quality or habitat impairments. Tracking these "impaired waters" is required under Section 303(d) of the Federal Clean Water Act. Each impairment that is identified in the list of impaired waters may require preparation of a Total Maximum Daily Load (TMDL) to address the water quality and/or habitat impairment in the affected water body.[5] Maryland's list of impaired waters for Calvert County's portion of the Lower Patuxent River watershed includes water quality and habitat problems:

- Biological Limitations (poor or very poor fish or benthic organism populations/conditions)
- Fecal Coliform Bacteria
- Methylmercury and Fish Consumption Advisory
- Nutrients (nitrogen and phosphorus)
- Sediment
- Toxic Compounds (chlorpyrifos)

These impairments affecting portions of the WRAS project area are addressed below in alphabetical order. Each water body listed may require preparation of a Total Maximum Daily Load (TMDL) to address the water quality and/or habitat impairment.[4]

1. Biological Impairment

In selected stream segments statewide, 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. In the WRAS project area, nine stream nontidal stream sites appear in the list because of biological impairment. See the section on Maryland Biological Stream Survey Findings for additional details.

2. Fecal Coliform Bacteria and Shellfish Harvesting Restrictions

In the Lower Patuxent River watershed in Calvert County, excessive levels of fecal coliform bacteria are listed for the portions of several tidal water bodies: Battle Creek, Buzzard Island Creek, Island Creek, Mill Creek and Solomons Island Harbor.

Fecal coliform bacteria are a class of bacteria typically found in the digestive tract of warm-blooded animals, including humans. They are always found in animal waste and human sewage unless it is treated to kill them. In unpolluted streams and tidal waters, it is common for water samples to contain very few of these bacteria. Water samples exhibiting significantly larger fecal coliform bacteria populations are "indicators" of contamination by animal, including human, waste. Depending on local conditions, sources of fecal contamination may include any combination of the following: inadequately treated sewage, failing septic systems, wild or domestic animals, urban stormwater carrying pet waste and similar sources.

When fecal coliform bacteria levels are too high in tidal waters containing shellfish, harvesting is restricted to prevent consumption of contaminated food. As shown in Map 3 Designated Uses and Use Restrictions, portions of Patuxent River and its tributaries are affected by regulatory limitations on shellfish harvesting. The following shellfish harvesting waters are "restricted" which "means that no harvesting of oysters and clams is allowed at any time":

- Four Patuxent River tributaries: Battle Creek, Buzzard Island Creek, Island Creek and Solomons Island Harbor
- One large area of the Patuxent River mainstem upstream of Gods Grace Point

Also shown on Map 3, a large area of the Patuxent River is designated as "conditionally approved waters" which "means that oysters and clams can normally be harvested except for the three days following a rainfall of an inch or greater in 24-hours." This area is approximately between Gods Grace Point and the area near Buzzard Island Creek.

These restrictions are applied by the Maryland Dept. of the Environment (MDE) to protect public health because elevated fecal coliform counts are commonly found in this area of the Patuxent River estuary. The elevated counts suggest the presence of contamination by animal or human waste. Restrictions are necessary because oysters and clams are filter feeders that readily absorb pathogens in animal or human waste.

3. Methylmercury and Fish Consumption Advisory

Lake Lariat is listed as an impaired water body for methymercury. This metal compound is a concern because largemouth/smallmouth bass in the lake were found to contain levels of methylmercury that could cause human health problems if these fish are eaten too frequently. Fish tissue sampling conducted in 2001 by MDE led to issuance of a fish consumption advisory in late 2001. The purpose of the advisory is to recommend very limited human consumption of largemouth/smallmouth bass from Lake Lariat: 1) only one 8 oz. meal per mouth for the general population and 2) children should not consume these fish. For more information see http://www.mde.state.md.us and search for "fish/shellfish".

Methylmercury accounts for the majority of mercury found in these fish. It is also the form most readily absorbed and retained in the human body. Mercury may enter the lake in various chemical forms but biological activity tends to generate methylmercury from other forms of mercury.

The amount of methylmercury in individual fish varies in any given water body. In general, larger older fish contain more compounds that bioaccumulate like methylmercury than smaller younger fish. Therefore, it is safer to eat smaller younger fish. However, the average concentration of methylmercury in fish tested from Lake Lariat was among the highest compared to fish tested from other impoundments in Maryland.[12]

In general, it is believed that the mercury entering the Lake Lariat aquatic food chain and accumulating in largemouth and smallmouth bass reaches the lake in rainfall and dust (atmospheric deposition). The primary source of atmospheric mercury is burning coal. Other sources include incineration of trash (including dry cell batteries and mercury switches that are thrown away). Also see the section on the Lake Lariat TMDL for mercury.

Based on information accumulated to date, there appear to be several approaches to reducing accumulation of mercury compounds in water bodies:[12]

– Reduce incoming mercury by minimizing deposition (frequently beyond local control);
– Reduce movement of mercury from the land to water bodies in local watersheds by minimizing soil disturbance, maximizing forest cover and maintaining/restoring riparian buffers;
– In constructed wetlands, wetland design appears have an effect on the creation of the methylmercury from other mercury compounds. This suggests that some types of wetlands could be constructed that would have less methylmercury production compared other types of constructed wetlands.

4. Nutrients

The mainstem of the Patuxent River from its mouth to Ferry Landing is listed for impairment caused by nutrients.

Nutrients, phosphorus and nitrogen, are essential to support aquatic life but excess nutrients can cause problems. In Maryland, most water bodies naturally have low levels of the nutrients nitrogen and phosphorus. However, in the tidal waters of the Patuxent either nitrogen or phosphorus can become too readily available. When this occurs under certain conditions with warm weather, sufficient light, etc., algae populations can grow to excessive levels. These algae can then crowd out other small organisms, cloud the water limiting light penetration, and eventually die-off consuming the dissolved oxygen that other aquatic life needs to survive.

Nutrient pollution or over-enrichment problems may arise from numerous sources including all types of land and from the atmosphere. Residential land can be an important contributor of nutrients depending on fertilizer use, extent of lawn and the status of septic systems. Farmers apply nutrients using different approaches, so nutrients entering waterways from crop land vary greatly depending on management techniques. Typically, streams and other surface waters receive relatively small amounts of nutrients from forest land and relatively large amounts from land uses that involve soil disturbance and application of fertilizer. Most of the nutrients in the Lower Patuxent River watershed are generated within the Patuxent watershed. However, the atmosphere can contribute various forms of nitrogen produced by burning fossil fuels in power plants and other industries, and from automobiles.

5. Sediment

The mainstem of the Patuxent River from its mouth to Ferry Landing is listed for impairment caused by suspended sediment.

Suspended sediment can cause water quality and habitat problems in several ways. 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 generally. The amount of sediment contributed varies greatly from site to site depending upon stream stability, hydrology, management controls and other factors.

6. Toxic Compounds

The tidal portion of the lower Patuxent River is listed for impairment by toxics because a 1999 study found levels of the pesticide chlorpyrifos that are believed to be too high relative to other comparable water bodies. Chlorpyrifos is a synthetic compound manufactured and used for human purposes. However, the source of this impairment in the Lower Patuxent River is not known.

In general, a wide array of materials may be considered toxic substances because they exhibit poisonous, or lethal, or otherwise harmful affects to 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 [lake, estuarine and] 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 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

Total Maximum Daily Loads

The Maryland Department of the Environment (MDE) uses the 303(d) list to determine the need for establishing Total Maximum Daily Loads (TMDLs). A TMDL is the amount of pollutant that a waterbody can assimilate and still meet its designated use. A waterbody may have multiple impairments and multiple TMDLs to address them. MDE is responsible for establishing TMDLs in Maryland. In general, TMDLs include several key parts:

1- Maximum pollutant load that the water can accept while still allowing the water body to meet its intended use.
2- Allocation of the maximum pollutant load to specific pollutant sources.

As of October 2003, only one TMDL has been prepared that directly affects the WRAS project area -- the TMDL for Mercury in Lake Lariat. It can be anticipated that additional TMDLs will be prepared to address other water quality impairments in the Lower Patuxent River watershed.

1. Lake Lariat TMDL for Mercury

Currently, the draft *Total Maximum Daily Load of Mercury for Lake Lariat, Calvert County, Maryland* is under review by EPA for approval. A TMDL for mercury in Lake Lariat was prepared because of the current fish consumption advisory for largemouth/smallmouth bass. In order to protect human health, the advisory recommends limiting how frequently these fish from the lake are eaten because of methylmercury contamination. This advisory also means that the lake is not meeting its designated use under Maryland regulation. Therefore, a TMDL is necessary.

The TMDL is designed to allow the lake to meet its designated use for protection of aquatic life and recreational use which includes safe consumption of fish taken from the lake. MDE calculates that TMDL necessary to achieve this goal for Lake Lariat is 0.00331 grams per day (1.20815 grams per year). To reach this level would require about an 80% reduction from the current mercury load to the lake. MDE's calculations also indicate that nearly 84% of the mercury load to the lake is from atmospheric deposition and the remainder comes from nonpoint sources in the lake's watershed. There are no known point sources of mercury in the lake watershed.

The TMDL for Lake Lariat and addition TMDL information is available on MDE's Internet site.[5]

Water Quality Indicators–Setting Priority for Restoration and Protection

This comparison using indicators was first created to support the Clean Water Action Plan's 1998 *Unified Watershed Assessment* which established priorities for watersheds in the State for restoration and protection. In the Plan, there were two categories for priority action: highest priority for restoration, and priority for protecting valued resources.

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 looked at five water quality indicators to compare the State's 134 "8-digit" watersheds though not all watersheds had information to allow generation of each indicator.

Water Quality Indicator Summary
Lower Patuxent River Watershed
From: 1998 *Unified Watershed Assessment*

Indicator Name	Finding
Tidal Habitat Index	8.3
Tidal Eutrophication Index	7.5
Modeled Load: TP	0.52 lbs/acre
Modeled Load: TN	7.25 lbs/acre

Comparison with similar Maryland watersheds
Green shading: goal or benchmark was met.
Orange shading: goal or benchmark not met.

1. Tidal Habitat Index

In comparison to the other watersheds that drain to the Chesapeake Bay in Maryland using 1994-1996 data, the Lower Patuxent River watershed ranked "8.3" for tidal habitat index on a scale of 1(worst) to 10(best). This rank meets Maryland's benchmark for this index.

The tidal habitat index combins 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.). To create the 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 with the worst conditions, which ranked in the lowest quartile (25% of the watersheds), "exceeded" the benchmark.

2. Tidal Eutrophication Index

In comparison to the other watersheds that drain to the Chesapeake Bay in Maryland using 1994-1996 data, the Lower Patuxent River watershed ranked "7.5" for tidal habitat index on a scale of 1(worst) to 10(best). This rank meets Maryland's benchmark for this index.

The tidal eutrophication index combines three measurements of water quality (in surface mixed-layer water): total nitrogen, total phosphorus and total suspended solids. 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). Watersheds with the best conditions ranked in the highest three quartiles and, thereby, met the benchmark. The watersheds with the worst conditions ranked in the lowest quartile (25% of the watersheds) and "exceeded" the benchmark.

3. Modeled Loads for Phosphorus and Nitrogen

In comparison to the other watersheds that drain to the Chesapeake Bay in Maryland, it is estimated that the Lower Patuxent River watershed receives 0.52 pounds of total phosphorus (TP) per acre in the watershed and 7.25 lbs/acre total nitrogen (TN). Both of these nutrient yields meet Maryland's benchmarks for these nutrients used in the *Unified Watershed Assessment*.

Computer models are used to estimate how much TP and TN reaches the streams and how much of each is available for transport to the Bay. To generate the yield estimates reported in the Unified Assessment, the following information was used for the models: 1) monitoring data of point source nutrient discharges; 2) estimated nonpoint sources loads, based on 1996 land use and estimates of selected land management practices, and 3) consideration of other factors like deposition from the air.

2002 modeling conducted by DNR using 2000 data shows that the average yields for the Lower Patuxent watershed are 0.303 pounds per acre annually of total phosphorus and 5.57 pounds per acre annually of total nitrogen. These load estimates may differ from the estimates used in the *Unified Watershed Assessment* for several reasons: changes in point source discharges and land use, and differing consideration of best management practices and septic system loads.

An additional gauge of nutrient loads will be available in the results of the synoptic survey conducted in 2003.

Water Quality Monitoring and Assessment

1. Patuxent River Mainstem Status and Trends

To assist work of the Patuxent Tributary Team, DNR analyzed data from long term water quality monitoring stations in the mainstem of the Patuxent River shown on Map 4 Monitoring Water Quality to characterize water quality status and trends. In the summary table below, the status for each parameter in the table is a relative ranking at three levels: good, fair and poor. For example, good means the area's ranking is good relative to comparable Chesapeake Bay tributaries with comparable salinity. This information is from DNR's Internet site http://www.dnr.maryland.gov/bay/tribstrat/locator.html. [1, 9]

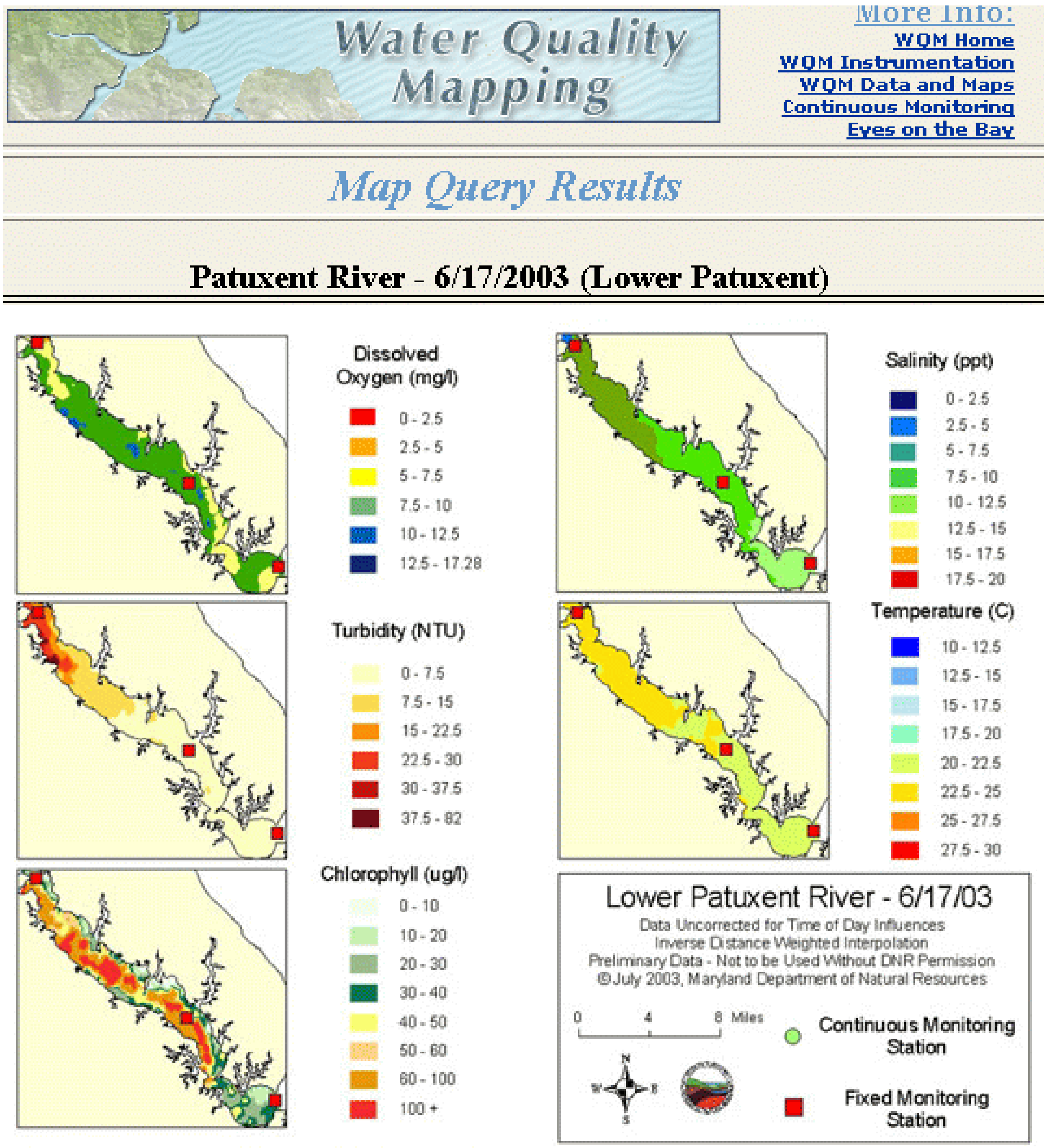
Status 1998 to 2001 and Trends 1985 to 2001
Long Term Water Quality Monitoring Stations

Mainstem Station Location	Total Nitrogen	Total Phosphorus	Algae	Total Susupended Solids	Secchi Depth	Dissolved Oxygen
Nottingham	^ 50%	^ 37%	---	^	---	---
Lower Marlboro	^ 39%	^ 32%	---	^	---	---
Above Benedict	^ 30%	^ 27%	---	---	---	- 16%
Below Benedict	^ 59%	^ 36%	- 62%	---	---	---
Jack Bay	^ 32%	^ 45%	---	^ 25%	---	---
St. Leonard	^ 12%	^ 36%	- 45%	---	- 14%	---
Above Pt. Patience	^ 18%	^ 32%	- 67%	---	- 15%	---
Drum Point	^ 15%	^ 30%	- 81%	---	- 11%	---

KEY: ^ = improving; — = no significant trend ; - = degrading

good conditions
fair conditions
poor conditions

DNR's Internet site includes large amounts of information relevant to the Lower Patuxent River watershed and Calvert County. The sample below maps water quality conditions for the Lower Patuxent River mainstem on June 17, 2003. This information is updated periodically. Visit the DNR home page at www.dnr.maryland.gov



2. Solomons Harbor

Water quality data for Solomons Harbor has collected since 1987 by the University of Maryland Center for Environmental Science for Calvert County. Parameters monitored included water temperature, salinity, dissolved oxygen, chlorophyll *a* and water clarity. Based on monitoring data collected beginning in 1987:

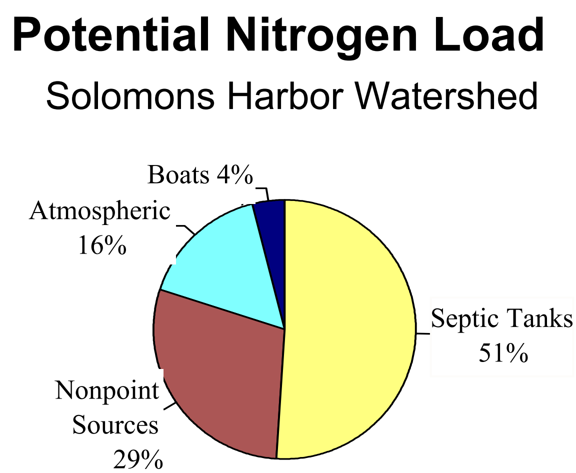
– Average dissolved oxygen in bottom water for each sampling year in less than 5.0mg/l. This finding appears to be related to stratification of the water column during warm weather.[17] Dissolved oxygen less than 2.0 mg/l has been observed at about 20% of the sampling sites during several sampling years.[19]

– Average chlorophyll *a* concentration is higher in wet years than dry years. In dry years (1992, 1995, 1999, 2002), the trend is toward increasing chlorophyll *a* concentrations. The highest chlorophyll *a* concentrations tend to be found in upstream tidal waters.[17] In 2000, chlorophyll *a* concentrations were as high as 90 micrograms per liter (Fg/l).[19]

– Water clarity as measured by secchi depth varied from 0.2 to 1.6 meters in 2000.[19]

– Salinity varies from 10 to 15 parts per thousand.[19]

Potential nitrogen loads in Solomons Harbor are shown in the pie chart:[17]



– 51% associated with septic systems. The percentage of nitrogen load that is potentially delivered to Solomons Harbor has not been determined but it could be between 30% and 50% of the total load;

– 29% from nonpoint sources (land) in the Solomons Harbor watershed;

– 16% is atmospheric deposition of nitrogen is associated with smoke emissions from electric utilities burning fossil fuels, tailpipe emissions from automobiles, natural exchange with the air, and;

– 4% is discharge of treated sewage from onboard boats into waters of the Solomons Harbor.

3. Hunting Creek

Samples were collected every other week from March to November beginning in June 1998 running through July 2001 at one site on Hunting Creek near Twirley Hole. Parameters collected were temperature, salinity, secchi depth, total suspended solids (TSS), chlorophyll-a (chl-a), nitrates + nitrites (NO23), ammonium (NH4), and phosphates (PO4).

This area of Hunting Creek is tidal fresh with salinity ranging from 0 to 13 parts per thousand (ppt). In general, salinity was higher in dryer years of 1998 and 1999 than in the wetter years of 2000 and 2001.

Total suspended solids averaged about 37 mg/l (standard deviation of about 24 mg/l). However, several samples were much higher – around 100 mg/l. TSS tended to be lower during high rainfall periods (high correlation of TSS v salinity) and higher during high tide. This suggests that the tide contributes more TSS than upstream flows. In upstream fresh water areas sampled independently by Calverton School, TSS were found to be higher in a subwatershed with a higher percentage of farmland rather than commercial or woodland acreage.

Dissolved phosphorus (PO_4) tended to be less than 0.04 mg/l. Peaks over 0.1 mg/l were observed. It tended to be higher during low salinity (high fresh water flows) and during high salinity and high temperature. The correlation with salinity and high temperature suggests that the bottom sediments become anoxic during these periods. It is likely that anaerobic bacterial cause release of dissolved phosphorus from sediments which can then feed algae growth.

Nitrite and nitrate were found to be higher with higher rain fall and higher in upstream freshwater areas. This suggests that the watershed is an important nitrogen source in Hunting Creek. In sampling of upstream freshwater areas by the Calverton school, nitrates were found to be six times higher in a subwatershed with a higher percentage of farmland compared to subwatersheds with highs with greater areas of commercial or woodland acreage.

Chlorophyl *a*, which is one way to measure algae abundance, ranged from around 10 micrograms per liter (Fg/l) to between 50 and 60 Fg/l. The higher values are indicative of algae blooms and eutrophication. Peak Chl *a* concentrations tended to be in summer and sporadically in other seasons. Overall, there was a trend toward declining Chl *a* during the study period. Also, Chl *a* tended to be highest when salinity was between 3 and 9 ppt. This suggests that nitrogen and phosphorus were most available under certain tidal/rain fall conditions.

Hydrocarbon monitoring by the Calverton School in freshwater areas found the highest concentrations were associated with commercial and construction activities rather than farmland.

4. Island Creek

As part of the WRAS project, the University of Maryland Center for Environmental Science collected water quality data in Island Creek during summer 2003 to examine the relationship between local water conditions and boating. Two days of monitoring – one day with high boating activity and one with low activity – did not identify significant water quality effects from boat activity. Additional study would be needed to conclusively establish or rule out a relationship. The report, *The Effects of Boat Traffic on Chemical and Physical Parameters of Island Creek, Maryland*, should be available in early 2004.[26]

5. Nitrogen Source Assessment in Patuxent River Area Creek[18]

During 2003, the University of Maryland Center for Environmental Science analyzed samples from 67 sites in the Patuxent River / Island Creek area. From each site, samples of cultured organisms (either macroalgae, clams or SAV) were analyzed to measure relative amounts of the two atomic forms of nitrogen (^{14}N and ^{15}N). With this nitrogen isotope information, maps will be generated to show the likely source of the nitrogen (human or nonhuman). Additionally, water quality parameters measured at each site were total nitrogen, total phosphorus, chlorophyll *a*, secchi depth, salinity, temperature, dissolved oxygen and pH. A report is anticipated in 2004.

6. Nontidal Streams

Water quality sampling is conducted by the Maryland Biological Stream Survey as part of their assessment protocol at stations shown on Map 4 Monitoring Stations. Several overall findings can be drawn from their assessment which includes biological and water quality components:[16]

– Based on biology, Lyons Creek (outside of the WRAS area) rated the highest (best) among Calvert County Streams. Fishing Creek and Hunting Creek rated the lowest (poorest).

– Nitrate concentrations in Calvert County streams are typically in the 0.10 to 0.99 mg/l range as shown in the figure below. The highest nitrate concentration, 1.2 mg/l, was found in Lyons Creek. The other site with nitrate concentration of 1.0 mg/l or greater was in Schoolhouse Branch.

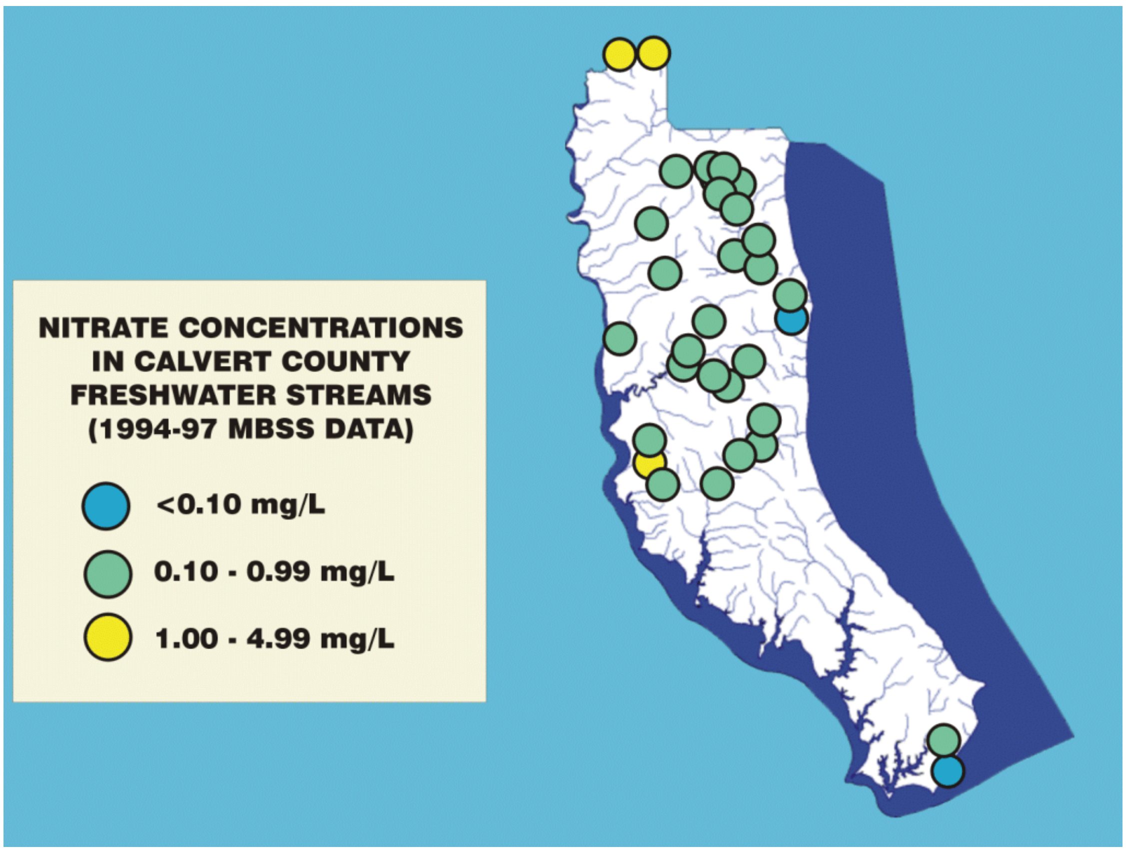


Figure is extracted from the May 29, 2003 presentation by Ron Klauda, DNR Resource Assessment Service at Calvert County's Comprehensive Plan Liaison Meeting on Environmental Issues.

7. Toxics In Tidal Waters

In 1999, the Chesapeake Bay Program released a report on toxic compounds found in tidal rivers in the Chesapeake Bay drainage. In the report, the tidal portion of the Patuxtent River mainstem was divided into three segments and each was classified based on the toxics assessment. In the summary below, "Area of Emphasis" means that available data for that tidal area indicates that there is a significant potential for a chemical contaminant-related problem:[21]

a. Upper Tidal Patuxent

This area of the Patuxent River mainstem upstream of Chaulk Point was labeled an Area of Emphasis. In general, pesticides found in the water (chlorpyrifos and malathion) and in sediment (DDT) were at levels indicating probable adverse effects on living resources.

In the lower portion of the segment water was slightly toxic to Chesapeake organisms in laboratory tests. Sediment in this area did not exhibit toxicity but polynuclear aromatic hydrocarbons were found at levels that indicate probable adverse effects on living resources.

In the middle portion of this segment, several sampling sites found degraded benthic communities. Dissolved oxygen was adequate so chemical contamination may be a cause.

b. Middle Tidal Patuxent

Between Chaulk Point and Sheridan Point, the Patuxent River mainstem was labeled as an Area of Emphasis. Sheridan Point is midway between Battle Creek and Rt. 231.

In the upper portion of this segment, levels of the pesticide chlorpyrifos in the water and sediment were high enough to indicate probable adverse effects on living resources.

In the lower portion of this segment, metals and the pesticide DDT levels were high enough to potentially cause adverse effects to living resources. Both water and sediment from this area caused adverse effects on Bay organisms under laboratory conditions.

c. Between Sheridan Point and the mouth of the Patuxent River

This portion of the Patuxent River mainstem was labeled "Area with insufficient or inconclusive data." In general, the available data did not provide sufficient evidence of a widespread chemical contamination problem in this segment. However, local areas were found to exhibit chemical contamination issues.

Water samples from near Broomes Island caused adverse effects on Bay organisms under laboratory conditions. In this test, the samples were found to be more toxic to animals that live in the water than most other waters tested (ranking third out of 46 stations representing 16 tidal rivers around the Chesapeake Bay.) In this area, sediment toxicity was not identified but benthic communities were degraded. The pesticide Endosulfan II was found at levels high enough to indicate probable adverse effects on living resources.

Sources of Pollution

Since European settlement of North America there has been an explosive growth in human population, supported by more intensive agriculture and the growth of industry. The entire continent has been cris-crossed and made mutually interdependent by vast transportation systems. All of this contributes to the decline in quality of our water and other natural resources.

1. MDE Permits and Point Sources

Discharges from pipes or other "discrete conveyances" are called "point sources." Point sources may contribute pollution to surface water or to groundwater. For example, wastewater treatment discharges may contribute nutrients or microbes that consume oxygen (measured as Biochemical Oxygen Demand (BOD)) reducing oxygen available for other aquatic life. Industrial point sources may contribute various forms of pollution. Some understanding of point source discharges in a watershed can be useful in helping to identify and prioritize potential restoration measures.

For the Lower Patuxent Watershed, 30 permits from the Maryland Department of the Environment (MDE) permit data base are summarized in the following tables and on Map 5 MDE Permits. Based on this information, several findings can be reported:

– None of the permitted discharges area appear to be significant contributors to the use impairments listed for the WRAS project area.
– Discharge of treated sewage effluent is permitted for four groundwater discharges (spray irrigation, etc.) and one small point source discharge
– Marinas with permitted discharges are concentrated in the vicinity of Solomons.

MDE Permits Summary Table – General Permits For Marinas Lower Patuxent Watershed (2/2003 data) Page 1 of 3		
Name	**MD Permit / NPDES Permit**	**Watershed Street Location**
Back Creek Boat Yard	02MA9262	S. Solomons Is. Rd., Solomons
Harbor Island Marina, Inc.	02MA9129	Charles Street, Solomons
Spring Cove Marina	02MA9101	Lore Road, Solomons
Spring Cove Marina	01SI6468 / MDG766468	Lore Road, Solomons
Town Center Marina	02MA9141	Alexander Lane, Solomons
Washburn's Boat Yard, Inc.	02MA9139	Dowell Road, Solomons
Zahniser's Yachting Center	02MA9102 / MDG999102	C Street, Solomons

MDE Permits Summary Table – Sanitary, Industrial and Stormwater Permits Lower Patuxent Watershed (2/2003 data) Page 2 of 3				
Type / MDE Category		**Name**	**MD Permit / NPDES Permit**	**Receiving Stream / Watershed Street Location / Description**
Surface Water	Sewage Effluent	Northern High School	97DP1092 MD0052167	Graham Creek Flint Hill Road, Owings
	Industrial	Academy of Science	98DP0554 MD0003093	Patuxent River, Mackall Rd, St. Leonard research organization
		U of Maryland Chesapeake Biological Lab	00DP2187 MD0061051	Patuxent River, Farren Ave., Solomons research organization
		Cove Corp.	00DP3018	St. Leonards Creek, Breeden Rd, Lusby agricultural research
		Splash 'N Dash	98DP3248	Trib. to Hunting Ck, Rt 2/4, Huntingtown car wash
	Stormwater	US Navy Rec. Complex	97SW0300	Patuxent River, Route 2/4, Solomons US security
Groundwater	Sewage Effluent	Calvert Co. Industrial Park	01DP3173	Skipjack Rd, Barstow
		Prince Frederick WWTP	00DP2705	Sugar Notch Rd, Barstow spray irrigation
		Shoppes At Apple Green	02DP3400	Dunkirk Way, Dunkirk spray irrigation
		Solomons Island WWTP	98DP2178	Sweetwater Road, Lusby

MDE Permits Summary Table – General Permits Other Than Marinas Lower Patuxent Watershed (2/2003 data) Page 3 of 3			
Name		**MD Permit / NPDES Permit**	**Watershed Street Location**
Concrete Mix	Chaney Enterprises	00MM9872 MDG499872	Skipjack Road, Prince Frederick
	Howlin Concrete, Inc.	00MM9857 MDG499857	Stafford Road, Barstow
	Howlin Concrete, Inc.	00MM9856 MDG499856	E. Chesapeake Beach Rd, Owings
	Tessa Structures, LLC	00MM9744 MDG499744	Rt. 231, Barstow
Water Supply Discharge	Chesapeake Ranch Water Company	00HT9568 MDG679568	HG Trueman Road, Lusby
	Hunting Hills Water System	00HT9548 MDG679548	Well Street, Huntingtown
	Lakewood Estate Water System	00HT9541 MDG679541	Maplewood Drive, Dunkirk
	Shores of Calvert Water System	00HT9539 MDG679539	Riverside Drive, Dunkirk
	Solomons Island Water Dist. System	00HT9538 MDG679538	HG Trueman Road, Lusby
	White Sands Water System	00HT9552 MDG679552	White Sands Drive, Lusby
Other	Solomons Landing	01SI6107 MDG766107	Run-About Loop, Solomons swimming pool at apartment building
	Southern Maryland Oil, Inc.	2003OGT4456 MDG344456	Hall Creek, Thomas Ave., Owings bulk petroleum products
	Calvert County Industrial Park	00HT9549 MDG679549	Skipjack Road, Barstow
	US Navy Recreation Complex	02MA9207	Solomons Island Rd, Solomons US security

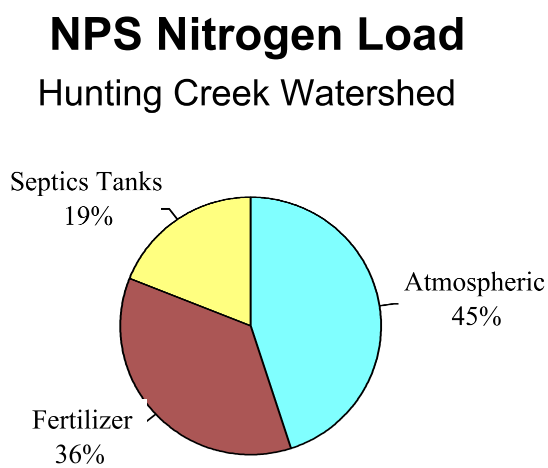
2. Diffuse or Nonpoint Sources

Sources of pollution that include areas of land and other sources that do not have a specific point of origin are called nonpoint sources. Nonpoint sources are commonly significant contributors of pollutants, particularly nutrients and sediment. These diffuse sources include rain water that runs off roofs, streets and parking lots (sometimes via storm drains) into nearby surface waters, as well as run-off from farm fields and, to a much lesser extent, forests. Also included in nonpoint source pollution is deposition from the atmosphere and contributions from ground water, where septic systems are a factor.

Nonpoint sources account for the majority of nutrient loads generated in the WRAS project area. In the Solomons Harbor watershed, which is the most density developed subwatershed in the WRAS project area, septic systems probably account for between 35% and 50% of the nitrogen delivered to surface waters, other nonpoint sources account most of the remaining nitrogen and atmospheric deposition may account for 10%.[17]

In the Hunting Creek watershed, which is a relatively undeveloped rural subwatershed, Nitrogen sources were grouped into three general categories:

- 45% is estimated to come from atmospheric deposition (about 19 kg/ha);
- 36% is considered to be locally controllable nonpoint sources, including fertilizer use (about 15 kg/ha), and;
- 19% is estimated to be associated with septic systems (about 8 kg/ha).



Locally controllable nitrogen loads are projected to increase over 14% according to landscape modeling of build-out scenarios under current zoning. The model also predicts that under two growth management scenarios, increases in nitrogen between 7.5% and over 11% are likely.[20]

In the WRAS project area, septic systems appear to be a significant contributor of nitrogen to surface waters:[17]

– 25% of Calvert County's nonpoint source nitrogen is from septic systems according to a Maryland Department of Planning estimate.
– Septic systems serve more than 90% of Calvert County's residents.

3. Shoreline Erosion

Wherever land and open water meet, change in the form of erosion or accretion of land is the inevitable result of natural processes. Human activity in these areas often either inadvertently accentuates 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.)

Countywide shoreline erosion is summarized in the following table. These figures group together both Patuxent River and Chesapeake Bay shorelines. [7]

Calvert County Shore Erosion Rate Summary (Miles of Shoreline)				
Total Shoreline	Total Eroding Shoreline	Erosion Rate		
		0 to 2 feet / year	2 to 4 feet / year	4 or more feet / year
143	58 (41%)	45	9	4

Maps of historic shoreline change were produced in 1999 by the Maryland Geological Survey (MGS) in a cooperative effort between DNR and the National Oceanic and Atmospheric Administration (NOAA). These maps included digitized shorelines for several different years in Calvert County. The maps show that extensive changes have occurred adjacent to large bodies of open water. Copies of these 1:24000 scale maps are available from the MGS.

Currently, DNR is working to improve our ability to predict areas of high-rate shoreline erosion. In addition to considering historic erosion rates, contributory effects of land subsidence and sea level rise are being considered. To help generate predictive tools, two pilot areas have been selected: Calvert County and Dorchester County. Results from this work are not currently available but information will be shared with Calvert County and other interests when they become available.

Groundwater and Water Supply

1. Recent Use

All community water supply systems use groundwater in Calvert County. For the Patuxent side of the County, the table lists the withdrawal permits and Map 6 Community Water Systems shows their general location.

These community systems generally use two confined aquifers. The closest to the surface is the Piney Point-Nanjemoy aquifer and below it is the Aquia aquifer. Use of these confined aquifers avoids the potential of local near-surface pollution like septic tank effluent.

In 1994, withdrawals from the Aquia aquifer in the Solomons area (including Lexington Park, St. Mary's County) had caused water levels in the aquifer to drop to 131 feet below sea level according to the Maryland Geological Survey (MGS). As shown in Map 7 Aquia Aquifer, the cone of depression around Solomons Island dropped to around 140 feet below sea level by 1999.[24, 25] It is likely that more recent rates of withdrawal are continuing this trend.

2. Future Management

Groundwater use permitting allows withdrawals in a confined aquifer only to the permitted management level which is 80% of available drawdown. MGS Water use projections using Maryland Department of Planning population projections indicate that the Aquia aquifer management level could be reached within 25 years near Solomons Island and Chesapeake Ranch Estates. However, this outcome can be postponed or avoided by shifting reliance to the deeper Patapsco aquifer.[24, 25]

Community Water Systems
Calvert County, Patuxent River Watershed

Facility Name	Permit #
Cavalier Country	CA1970G004
Chesapeake Ranch Estates	CA1960G002
Hunting Hills	CA1959G101
Lakewood	CA1966G005
Beaches Water Company	CA1962G201
Prince Frederick	CA1974G005
St. Leonard	CA1986G007
White Sands	CA1956G002
Solomons Recreation Center	CA1993G048
Woodbridge - Mason Road	CA1978G008
Solomons	CA1984G003
Johnson Acres Water Co.	CA1980G003
Southern Pines Elderly Housing	CA1995G019
Tara Subdivision	CA1994G028
Walnut Creek	CA1995G030
Cross Point Subdivision	CA1996G026
Marley Run	CA1999G018
Regency Manor Mobile Home Park	CA1959G003
Hallowing Point Trailer Point	CA1982G007
Buckler Mobile Home Park	CA1993G040

LANDSCAPE

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.

Landscape Indicators

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 Maryland's watersheds can be compared. The following sections identify the findings for the Lower Patuxent River Watershed from the 1998 Plan, with the exception of the population density, which is based on more recent Year 2000 Census data. These indicators relate to the entire Lower Patuxent River watershed, which is significantly larger than WRAS project area.

Landscape Indicator Summary
Lower Patuxent River Watershed
From: 1998 *Unified Watershed Assessment*

Indicator Name	Finding
Year 2000 Population Density	0.37 people/acre
Historic Wetland Loss	42,599 acres
Unbuffered Streams	10 %
Soil Erodibility	0.26 value/acre

Comparison with similar Maryland watersheds
Green shading: goal or benchmark was met.
Orange shading: goal or benchmark not met.

1. Population Density

Based on the Year 2000 Census, the population density in the Lower Patuxent River Watershed was 0.37 people per acre of land. This differs from the 0.72 people/acre shown in the *Unified Watershed Assessment* which used 2000 population projections. 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, the effects of human activity that degrades, displaces, or eliminates natural habitat also tend 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.

2. Historic Wetland Loss

The Lower Patuxent River Watershed is estimated to have lost nearly 42,599 acres of wetlands over the years. This is a relatively large loss of wetlands 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.

3. Unbuffered Streams

Approximately 10% of streams in the Lower Patuxent River Watershed were not buffered with trees, based on 1998 information. This finding indicates that other comparable Maryland watersheds tend to have more streams with buffers. Corridors 100 feet wide (50 feet either side) along streams were combined with forest cover to develop this indicator. 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..[2]

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.)

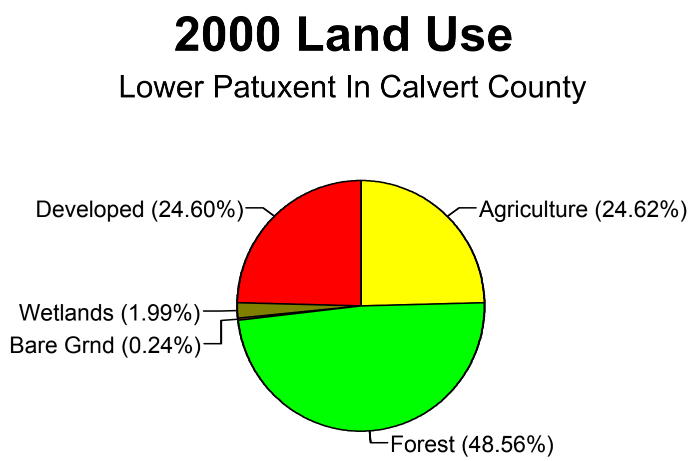
4. Soil Erodibility

Soil erodibility for the Lower Patuxent River Watershed is represented by what is known as the K factor, in this case estimated to be 0.26.[2] The K factor normally varies from approximately zero to about 0.6. In general, K value of 0.17 has a very low erosion potential, a value of 0.32 has a moderate erosion potential, a value of 0.37 has a high erosion potential, and a value of 0.43 has a very high erosion potential. The Lower Patuxent River watershed's overall erodibility is moderate, although its ranking among all watersheds in the state was fairly high.

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 cropland management was not considered.) The naturally erodible soils in the watershed are addressed by techniques called Best Management Practices (BMPs) to prevent soil loss, practices that are typically in use on local farms. BMPs like no-till or reduced till cropping, planting cover crops, field strips, or retiring erodible soils from production can significantly reduce erosion and sediment movement. These BMPs can be seen in use in many places in the watershed.

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.

Land Use



The following table and pie chart summarize 2000 land use / land cover for the Lower Patuxent Watershed as categorized by the Maryland Department of Planning.

Nearly half of the land in WRAS project area, Cavlert County's portion of the Lower Patuxent Watershed, is forest or brush. Both agricultural land and developed land occupy nearly one quarter of the WRAS project area. All other types of land together amount a little over 2% of land here.

Viewing these general land use categories as potential nonpoint sources of nutrients, agricultural lands are likely to contribute the greatest loads to local waterways. Urban lands may also contribute significant nutrient loads. Map 8 Land Use / Land Cover shows the distribution of these land use categories in the watershed.

2000 Land Use Summary Lower Patuxent Watershed in Calvert County		
Category	**Description**	**Acres**
Agriculture	Field, Pasture, farm buildings	23,441
Forest	All woodlands and brush	46,243
Developed Land	All developed areas	23,423
Wetlands	Tidal marsh, Emergent wetlands	1,891
Bare Ground	Beach, soil/rock, sand/gravel pits	229
Watershed Total – excluding open water		**95,227**
Watershed Total – including open water		**111,196**

Impervious Surface

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.

Urbanization and the increase in impervious surfaces that accompanies development can significantly impact stream health. Increases in the extent of upstream impervious surface are strongly associated with a decrease in stream quality. As impervious surfaces cover more of the landscape, less water infiltrates the soil and more water enters stream systems through runoff or stormwater discharge. This increased stormwater runoff from impervious surfaces contributes to stream quality degradation by introducing more non-point source pollution, higher temperatures, reduced stream baseflow and more erosive flood flow.

The table below shows the relationship between upstream impervious land cover and in-stream quality. These thresholds are based on extensive biological monitoring conducted by the Maryland Biological Stream Survey:[13]

Upstream Impervious Cover Thresholds	
Percent	**Affects on Stream Quality**
Less Than 2	Imperviousness is relatively insignificant compared to other factors affecting habitat quality. In cold-water habitats, brook trout may be found.
Above 2	Negative impacts to stream health begin. Brook trout are never found in streams with watershed imperviousness above this threshold.
Above 15	Stream health is never rated good, based on a combined fish and benthic macroinvertebrate Index of Biotic Integrity.
Above 25	Only hardy, pollution-tolerant reptiles and amphibians can thrive, while more pollution-sensitive species are eliminated.

Map 9 Impervious Surface Lower Patuxent River Watershed in Calvert County and the table Average Subwatershed Impervious Area, reflects data developed by the University of Maryland's Regional Earth Sciences Application Center (RESAC).[14] The map and table are color coded to show the relative average amount of impervious cover for each subwatershed. The map also shows higher concentrations of local impervious coverage as darker areas. The Solomans Harbor subwatershed is the only subwatershed in the WRAS project area exhibiting more than 2% average impervious area. In general, the subwatersheds having between 1 and 2% average impervious area tend to be located in the northern end of the Calvert County.

Map 10 Impervious Surface Solomons Harbor Subwatershed shows the distribution of impervious surface around the most urbanized portion of the WRAS project area. At this scale, it is readily apparent that impervious surface is concentrated near Solomons Island and the highway. The map also indicates that impervious surface is distributed throughout much of the subwatershed but the resolution of the data limits the accuracy of the rendering.

These findings from the two maps and table indicate that impervious surface is not significant at the watershedwide scale but it may generate locally significant impacts on water quality and habitat.

Average Subwatershed Impervious Area	
Subwatershed Name	**Percent**
Hall Creek	1.4
Graham & Friday Creeks	1.8
Chew Creek	1
Cocktown Creek	1
Hunting Creek	1.4
Deep Landing	0.5
Ramsey & Caney Creeks	1.3
Battle Creek Headwaters	0.7
Buzzard Island	0.9
St. Leonard Creek	0.9
Battle Creek - Lower	0.4
Island Creek	0.7
Solomons Harbor	2.9
Overall Average Impervious Area Calvert County Portion of the Lower Patuxent River Watershed	1.2

Lands With Significant Natural Resource Value and Large Area

Forest lands in the McIntosh Run watershed have been identified as important natural resource and habitat area by two different programs: DNR's Green Infrastructure model and The Nature Conservancy's ecoregion-based planning process. These independent programs agree on emphasizing the ecological value of the watershed and the importance of maintaining its extensive, contiguous forest.

In general, actions taken to assure that forest cover will be maintained, to avoid fragmentation of forest, and to restore forest in areas that have been cleared will contribute significantly to improving the water quality in this watershed and to conserving the biodiversity of the State.

1. Green Infrastructure

DNR has mapped a network of ecologically important lands, comprised of hubs and linking corridors, using several of the GIS data layers used to develop other indicators. Hubs contain one or more of the following attributes:

- areas containing sensitive plant or animal species;
- large blocks of contiguous interior forest (at least 250 contiguous acres, plus the 300 foot transition zone);
- wetland complexes with at least 250 acres of unmodified wetlands;
- streams or rivers with aquatic species of concern, rare coldwater or blackwater ecosystems, or important to anadromous fish, and their associated riparian forest and wetlands; and
- conservation areas already protected by public (primarily DNR or the federal government) and private organizations like The Nature Conservancy or Maryland Ornithological Society.

This "Green Infrastructure" provides the bulk of the state's natural support system. Ecosystem services, such as cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, protecting areas against storm and flood damage, and maintaining hydrologic function. For more information on the Green Infrastructure identification project in Maryland, see http://www.dnr.maryland.gov/greenways/gi/gi.html

Protection of Green Infrastructure lands may be addressed through various existing programs including Rural Legacy, Program Open Space, conservation easements and others. Within Program Open Space, the Green Print program helps to target funds to protect Green Infrastructure areas.

Map 11 Green Infrastructure shows that there is a significant amount of Green Infrastructure in the Lower Patuxent Watershed:

– Numerous Green Infrastructure hubs are identified in the WRAS area. In several subwatersheds, they are concentrated upstream of tidal waters (Hunting, St. Leonards, Battle, Helen and St. John Creeks). Further north, the hubs are concentrated near the Patuxent River mainstem in the vicinity of Kings Landing and Hall Creek.

– Several areas of the watershed have partial protection of Green Infrastructure hubs: Hall Creek, Kings Landing, Battle Creek and Hellen Creek (around the County Landfill). The natural resource values in most Green Infrastructure hubs are not protected.

2. Forest Interior in 1997

Large blocks of forest provide habitat for species that are specialized for forest interior conditions with relatively little influence by species from open areas or humans. For example, forest interior dwelling species (FIDS) require forest interior habitat for their survival and they cannot tolerate much human presence.

Map 12 Contiguous Forest 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 locally significant habitat for sensitive forest interior dwelling species. The assessment shown in Map 12 differs from the Green Infrastructure assessment which considered only large blocks of forest land cover at least 250 acres in size that are likely to have state or regional importance.

3. Projected Forest Interior Loss

Calvert County is located within an important flyway for neo-tropical, migrant birds and it may provide important breeding grounds for these species. In a 1999 County report, estimated potential forest loss and FIDS habitat loss was estimated based on projected build-out scenarios of current zoning. The definition used for FIDS habitat was at least 100 acres of contiguous forest that is at least 100 meters from a forest edge. Using 1992 topographic and orthophotographic GIS maps, forest cover in the County was estimated to cover 81,781 acres or 58% of the land. Of this, potential FIDS habitat accounted for about 37% of the forest (22% of the land). It was also estimated that about 44% or 13,523 acres of FID bird habitat was protected through either preservation or regulation.

A GIS computer model was developed to project three scenarios for land use change based on build-out under existing land use controls. Data layers used were forest data, zoning/zoning regulations, protected lands, floodplains and wetlands. Additionally in the southern part of Calvert County, data for slopes greater than 25% and parcels from tax maps were also considered. The three scenarios considered land use change with either random forest loss, minimizing FIDS habitat loss parcel by parcel, or minimizing forest interior loss regardless of parcel boundaries.

In the area studies, all three scenarios project that around one-third of the forest cover would be lost. Loss of FIDS habitat loss is projected to be between 54% and 65%. If these results were to occur Countywide, FIDS habitat would drop to less than 10% of the land area. At build-out in the absence of protection efforts or regulatory changes, 17,000 acres of FIDS habitat could be converted to developed land uses.

The model indicated that selected changes in zoning regulations could reduce FIDS habitat loss by about 11%.

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 low impact 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, etc. 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.

In Maryland, the designated Priority Funding Areas identify areas in which State funding is more likely to be available in support of local development projects. These areas are one of several ways to anticipate where new development or redevelopment is likely to occur. The table below shows that about 10% of the Lower Patuxent River watershed in Calvert County has this designation.

For purposes of watershed restoration, a knowledge of existing protected lands and likely areas for new development 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.

Map 13 Protected Land shows the distribution of protected lands and Priority Funding Areas. The adjacent table shows that various types of land that are protected from development account for about 7% of the land in the Lower Patuxent River watershed in Calvert County.

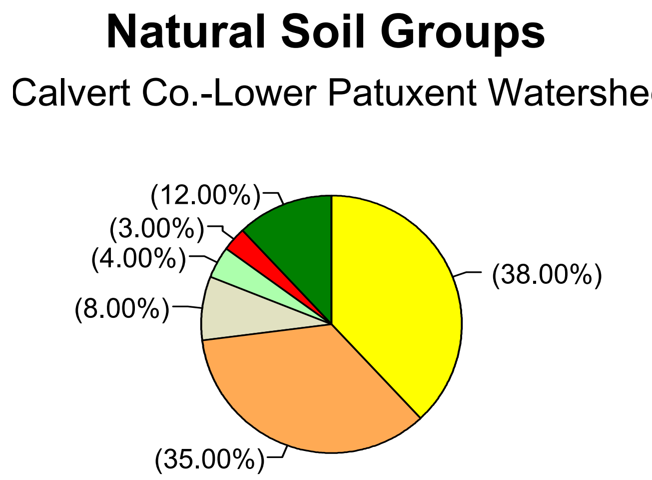
The Rural Legacy Area shown on the map and listed in the table refers to an area where Program Open Space funds may be targeted to help protect the land from development. Some of this land is already protected by easement and/or by County ownership. The land shown on the map that is not currently under easement or County ownership is open to land use change consistent with local zoning and comprehensive plan requirements.

Protected Land / Priority Funding Area
Lower Patuxent River Watershed
In Calvert County

	Acres	%
MET Easements	859	1
Private Conservation Easementst	178	--
Agricultural Easements	2,967	3
DNR Land	1,522	1.5
County Parks, Open Space	1,452	1.5
Federal Land	283	--
Protected Land Total	**7,261**	**7**
Rural Legacy Area	5,666	6
Priority Funding Area	9,648	10

Soils

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 Calvert County shows. This information has been summarized into Natural Soil Groups to help identify useful generalizations about groups of soils.

Map 14 Soils shows the distribution of natural soils groups in Calvert County's portion of the Lower Patuxent Watershed. The pie chart and table Natural Soil Group Summary gives details about the mapped soils. (clockwise from 12 o'clock):

– 38%: Prime farmland soils;
– 35%: Well drained soils with slopes greater than 8%;
– 8%: Sandy, excessively well drained soils;
– 4%: Soils with limitations not covered in other categories;
– 3%: Various hydric soils not associated with floodplains, marsh or swamp, and;
– 12%: Wet floodplains, marsh and swamp.

2. Soils and Watershed Planning

Local soil conditions can be a useful element in watershed planning and for targeting restoration projects. Soils with limitations like wetness or slope naturally inhibit active use for farming or development and may then be available as restoration project sites. By comparing Map 14 Soils with the preceding maps listed below, it may be possible to discern how patterns of active or passive land use relate to soil conditions:

– Map8 Land Use / Land Cover
– Map 11 Green Infrastructure

Natural Soils Groups and other soils assessments can be used to help identify potential areas for restoration projects or habitat protection. Hydric soils, for example, are more easily restored as wetlands than soils that were never saturated with water.

Natural Soil Group Summary Lower Patuxent River Watershed In Calvert County			
	Soil Group Description	**Area in Acres**	
Prime Agricultural Soils	B1a - Well drained, moderate erodibility.	27,661	35,821
	E1a, E1b - Moderately well drained, low erodibillity.	2,033	
	E3a - Moderately well drained, high erodibility.	5,879	
	G1 - Well drained floodplain	248	
Soils With Limitations for Farming	B1b, B1c - Similar to B1a but greater than 8% slope and greater than 15% slope respectively.	33,820	44,921
	A1a, A1b, A1c - Sandy, excessively well drained	7,703	
	B2a, B2b, B2c - Well drained with slowly permeable sublayers. Strongly to very strongly acid.	2,958	
	BP - Borrow pit (sand and gravel mine, etc.)	70	
	E2a - Seasonally wet or dry, perched watertable, strong acidity	370	
	H1a - Stoney	50	
Hydric Soils	F2 - Poorly or very poorly drained, strongly to extremely acid, low erodibility.	73	14,390
	F3 - Poorly drained to various extents – clayey, sticky and plastic when wet. Very high erodibility.	2,713	
	G2 - Poorly and very poorly drained floodplains subject to flooding, seasonally wet.	10,134	
	G3 - Marsh and swamp	1,470	

Wetlands

1. Wetland Categories

The Coastal Plain Province likely has the highest diversity of emergent estuarine and palustrine (fresh water) wetland communities relative to other Maryland physiographic regions because both tidal and nontidal freshwater marshes occur here. Wetlands are most abundant in the Coastal Plain due to the low topographic relief and high ground water table characteristic of the region.

Estuarine Wetlands. Estuarine wetlands are abundant throughout the Coastal Plain. These systems consist of salt and brackish tidal waters and contiguous wetlands where ocean water is at least occasionally diluted by freshwater runoff from the land. These wetlands may extend far upstream in tidal rivers to freshwater areas. Differences in salinity and tidal flooding within estuaries have a significant effect on the distribution of these wetland systems. Salt marshes occur on the intertidal shores of tidal waters in areas of high salinity. Brackish marshes are the predominant estuarine wetland type in Maryland. They are found along the shores of Chesapeake Bay, mostly on the Eastern Shore, and for considerable distance upstream in coastal rivers. Estuarine shrub swamps are common along the Maryland coastal zone. Aquatic beds, comprised mostly of submerged aquatic vegetation (SAV), were historically abundant in shallow water zones of Maryland's estuaries, especially Chesapeake Bay and its tributaries.

Lacustrine wetlands. These wetlands are associated with lakes and are relatively uncommon in Maryland.

Palustrine wetlands. These are freshwater wetlands that are not associated with streams or lakes. In general, palustrine wetlands are associated with freshwater, high water tables or intermittent ponding on land. Forested wetlands are the most abundant and widely distributed palustrine wetland type on the Coastal Plain. 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 represented in the Lower Patuxent Watershed. 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.)

Riverine wetlands. These wetlands are associated with streams or rivers.

2. 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 table Tracking Nontidal Wetland Change shows, the State regulatory program has measured a small net decrease of wetland acreage in the Lower Patuxent Watershed over the past 11 years. This slowing of wetland loss in the watershed contrasts significantly with the estimated historic 42,599 acre wetland loss in the watershed as described in the Landscape Indicators section.

Tracking Nontidal Wetland Change For The Lower Patuxent River Watershed In Acres 1/1/1991 through 12/31/2002 [10]				
Permanent Impacts	**Permittee Mitigation**	**Programmatic Gains**	**Other Gains**	**Net**
-10.65	10.02	0	0.39	-0.25

Notes: 1) Regulatory tracking for authorized nontidal wetland losses began in 1991. Comprehensive tracking of voluntary wetland gains began in 1998. Only nontidal wetland changes are shown; tidal wetland changes are excluded. Acreage presented covers the entire watershed; it does not identify County and it is not normalized. For example, the listing for the Lower Patuxent River includes five Counties: Anne Arundel, Calvert, Charles, Prince George's and St. Mary's.
2) "Permanent Impacts" refers to acres altered (e.g., filled, drained) under permit from MDE.
3) "Permittee Mitigation" refers to acres restored by a permit holder as required by terms of the permit from MDE.
4) "Programmatic Gains" refers to acres restored by MDE using fees paid into a compensation fund by a permit holder in lieu of undertaking mitigation himself.
5) "Other Gains" refers to acres of wetlands restored when not required as mitigation for permitted losses.

3. Interpreting Wetland Distribution

Wetland Acreage Summary Table summarizes distribution and categories of wetlands in the Lower Patuxent Watershed for Calvert and Anne Arundel County. Overall, two wetland categories account for nearly 100% of the wetlands in the watershed:

– In Calvert County's portion of the Lower Patuxent River watershed, 6.5% of the watershed (not counting open water) is wetlands. Here, about 32% of the wetlands are estuarine and about 67% are palustrine (fresh water). The lacustrine (lake) wetlands noted in the summary table refer primarily to Lake Lariat.

– Anne Arundel County's portion of the watershed is entirely headwaters. The condition and extent of wetlands here affects conditions downstream in Calvert County. Three percent of the watershed is wetlands and they are entirely palustrine.

Map 15 Wetlands: Island Creek Area presents the wetlands types in a selected portion of the WRAS project area. It shows that wetlands are generally associated with streams or estuarine waters.

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.)

Wetland Acreage Summary Table Lower Patuxent Watershed in Calvert and Anne Arundel Counties				
Wetland Class		Area In Acres		
		Calvert	Anne Arundel	Total
Estuarine	emergent	1,939	--	1,939
	forested	9	--	9
	scrub shrub	32	--	32
	unconsolidated bottom	6	--	6
	unconsolidated shore	35	--	35
Lacustrine	unconsolidated bottom	81	--	81
Palustrine	aquatic bed	60	4	64
	emergent	195	13	208
	forested	3,394	68	3,462
	scrub shrub	284	7	291
	unconsolidated bottom	328	6	334
	unconsolidated shore	7	--	7
Riverine	unconsolidated bottom	1	--	1
Total Wetlands		6,371	98	6,469

Floodplains and Low Elevation Areas Subject to Sea Level Rise

Map 16 Floodplains: Island Creek Area shows that the 100-year floodplain is primarily adjacent to estuarine waters in this part of the WRAS area. The scale and general location of floodplains across the WRAS Project Area are similar to that shown in this map.

Most areas of the Lower Patuxent Watershed have sufficient elevation to be unaffected by any potential for sea level rise in the next 50 to 100 years. However, marshes and other low-lying wetlands are at risk for inundation.

As a gauge of the risk posed by potential sea level rise, a Maryland-wide assessment of land at an elevation of 1.5 meters or less was first published in 1998 and then repackaged in a 2000 State report.[8] At the scale that the assessment was conducted, no part of the WRAS Project Area was singled-out as an area of concern from a statewide perspective.

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 as it becomes available.

LIVING RESOURCES AND HABITAT

Living resources, including all the animals, plants and other organisms that call the land and waters of the Lower Patuxent 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 alteration and destruction 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, etc. For example, information on many forms of aquatic life, woodland communities, terrestrial habitats, etc. 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 as it becomes available.

Living Resource Indicators

Aquatic organisms are sensitive, in varying degrees, to changes in water quality and aquatic habitat. They are also sensitive to landscape changes. 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 to gauge local conditions for water quality, habitat, etc. This second perspective is the basis for using living resources as an "indicator."

The *Maryland Clean Water Action Plan's Unified Watershed Assessment,* published in 1998, included a number of living resource indicators for the Lower Patuxent River Watershed.[2] Several of these indicators rely on extrapolations from a limited number of sampling sites which were then generalized to represent entire watersheds. Some are indices comprising several conditions. Considering this limitation on field data, it would be beneficial to conduct additional assessments to provide a more complete understanding of local conditions.

Living Resource Indicator Summary
Lower Patuxent River Watershed
From: 1998 *Unified Watershed Assessment*

Indicator Name	Finding
SAV Abundance	1.0
SAV Habitat Requirements	3.3
Tidal Benthic	4.67
Tidal Fish	5.0
Anadromous Fish Index	7.59
Nontidal Fish Index	7.7
Nontidal Benthic Index	5.8
Nontidal Habitat Index	4.4

Comparison with similar Maryland watersheds
Green shading: goal or benchmark was met.

1. SAV Abundance

For tidal areas of the Lower Patuxent 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 used: 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 indicator 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 restoration". 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 Index

For tidal areas of the Lower Patuxent Watershed, the abundance of submerged aquatic vegetation (SAV) scored "3.3" 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". Lower Patuxent watershed is among the lowest scoring half of watersheds statewide on this indicator.

3. Tidal Benthic

The Lower Patuxent River score of 4.67 for Tidal Benthic Index of Biotic Integrity does not meet the benchmark established for benthic community restoration.

This index was created by using samples from 18 fixed sites in Maryland's tidal tributaries to determine of the benthic community at each site meets restoration goals considering species diversity, species composition, productivity, and trophic composition. If more than one sample site where in the same river system, index scores were averaged to generate a watershed score. These scores were ranked 1 (worst) to 10 (best). Scores less than 6 do not meet the restoration goal and scores of 6 or greater met the goal.

4. Tidal Fish

The Lower Patuxent River score of 5.0 for Tidal Fish Index of Biotic Integrity means that moderate disturbance to the fish community was observed.

The Index was created by using monthly data (July - September) collected at multiple sites sampled in each river system. Observations considered included total number of species, number of species comprising 90% of the catch, number of species in the bottom trawl, anadromous fish abundance, estuarine fish abundance, total fish abundances not considering menhaden and proportions of fish that eat plankton, fish or benthos. These data were normalized and ranked. A rank of 2 means severe disturbance to the fish community, a 5 rank means moderate disturbance and an 8 rank means minimal disturbance.

5. Anadromous Fish Index

To develop this index, anadromous fish and semi-anadromous fish were examined based on average catch per unit effort (CPUE). The CPUE was calculated for each sampling area on a yearly basis. The average rank for each river was calculated and used to create a 1 (worst) to 10 (best) scale. To create the benchmark for this indicator, the index scores for the watersheds were ranked highest to lowest and then divided into four groups each containing 25% of the watersheds (quartiles). The watersheds with the worst conditions, which ranked in the lowest quartile (25% of the watersheds), "exceeded" the benchmark. All the remaining watersheds in the higher three quartiles (75% of the watersheds) met the benchmark.

6. Nontidal Fish Index of Biotic Integrity

With an IBI score of 7.7, the Lower Patuxent Watershed met the benchmark set for the Nontidal Fish Index of Biotic Integrity (IBI).

The Index 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. Each watersheds score is an average of stream scores within the watershed. These watershed scores were ranked 1 (most degraded) through 10 (best condition). A score of less than 6 does not meet the benchmark set for this index. A score of 6 or greater meets the benchmark.

7. Nontidal Benthic Index of Biotic Integrity

With an IBI score of 5.8, the Lower Patuxent Watershed does not meet the benchmark set for the Nontidal Benthic Index of Biotic Integrity (IBI).

The nontidal 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. An index of 6.0 or less means that restoration is recommended and an index of 8.0 or higher means that protection is recommended.

8. Nontidal Habitat Index of Biotic Integrity (IBI)

The Lower Patuxent River watershed's low overall index of 4.2 for habitat biotic integrity suggests that this watershed has significant physical habitat concerns relative to similar Maryland watersheds. This rank corresponds to an MBSS score of 2.8 which is in the "poor" range for MBSS reporting. A rank less than 6 means that restoration is recommended.

This physical habitat indicator is developed for small (first- to third-order) non-tidal streams. It is based on several measures of in-stream habitat quality that are scored for each site based on observations of habitat condition in streams during sampling visits. The habitat measures rate the quantity and quality of physical habitat available in the stream for fish and benthic macroinvertebrate colonization and rate the degree to which the stream channel has been altered due to changes in watershed landscape.

The physical habitat characteristics are measured, scored, weighted, and summed to calculate the indicator for each sampled stream. A low score, or a decline in score over time, reflects both natural disturbances and human-induced alterations of the stream habitat relative to minimally-disturbed reference sites. The mean habitat score for watersheds is reported on a scale of 1 (most degraded) to 10 (best condition). The ranked scores were divided into four groups each containing 25% of the watersheds (quartiles). Watersheds with the best conditions ranked in the highest three quartiles and, thereby, met the benchmark. The watersheds with the worst conditions ranked in the lowest quartile (25% of the watersheds) and "exceeded" the benchmark.

Physical habitat conditions in non-tidal streams and rivers are influenced by land use and land cover patterns in the watershed, such as the destruction of riparian forests and increasing the area of impervious land cover. Other major influences are channelization, encroachment by livestock, and blockages to upstream/downstream movements of fish.

Fish

1. Anadromous and Estuarine Species

Map 17 Fish Status shows current knowledge on herring, white perch and yellow perch spawning areas in the Lower Patuxent watershed accumulated by DNR Fisheries Service. Available information indicates that most spawning for these species occurs upstream of Calvert County's midpoint. Key spawning areas include Lyons Creek, Hall Creek and Hunting Creek.

Yellow Perch fishing/spawning surveys were conducted in March 2002 by the Coastal Conservation Association Southern Maryland (CCASM) on about 20 streams in Southern Maryland. Of three Patuxent River tributaries surveyed in Calvert County, only Lyons Creek (outside the WRAS project area) exhibited a significant evidence of yellow perch spawning:[15]

– Lyons Creek (outside WRAS): fishing survey not conducted, 150 egg masses found
– Hunting Creek: no fish caught during three hours, one egg mass found
– Battle Creek: fishing survey not conducted, no egg masses found

St. Leonard Creek was stocked with about 2,300 yellow perch fry at the Parran Road bridge in May 2002. Sein net surveys in St. Leonard Creek documented the presence of "year zero" yellow perch but the origin of these young fish (stocked or natural) was not determined.[15]

2. Fish In Nontidal Areas

Map 17 Fish Status shows stream segments surveyed by the Maryland Biological Stream Survey (MBSS) in Calvert County's portion of the Lower Patuxent in 1994 and 1997. A detailed listing of fish species identified in each area appears in APPENDIX A Findings from MBSS Fish Surveys. The overall interpretation based on this information suggests that stream areas in the WRAS project area could be prioritized based on the potential to protect or augment existing fish populations and/or spawning areas.

– Hall Creek and Hunting Creek (and Lyons Creek outside of the WRAS project area) have significant spawning by herring, white perch and yellow perch based on available information. Spawning by these species is also documented in Battle Creek, St. Leonards Creek, Hellen Creek and Mill Creek.
– Only fish that are tolerant or moderately tolerant to variable water quality and habitat conditions were found in the nontidal stream segments that where surveyed. The fish species found in the greatest number of stream segments tended to be tolerant species.
– Hunting Creek had the greatest diversity of fish species among the streams survey in the WRAS area.
– The most common fish in Calvert County's nontidal streams is the eastern mudminnow.[16]

Algae

During the summer of 2003 harmful algae blooms were reported in several locations around the WRAS project area. Dense blooms such as these have resulted in areas of hypoxia, or low oxygen, a condition which is stressful to Bay life:

– Mahogany Tide (Prorocentrum minimum): blooms in the Lower Patuxent River mainstem
– Black Tide (Karlodinium micrum). Sufficient toxin to kill fish is produced with concentrations of at least 10,000 to 30,000 cells/ml.
  - Lower Patuxent River mainstem during May and June 2003.
  - St. Leonard's Creek experienced concentrations as high as 58,000 cells/ml.
    Chlorophyll *a* measurements in the surface layer were measured as high as 6,645 Fg/l 678 Fg/L at about 1 foot below the surface and 10 Fg/l or less below a depth of one meter. Commonly, 30 to 50 ug/l chlorophyll *a* may be considered elevated.
  - Battle Creek experienced blooms of lesser severity than St. Leonard's Creek.
– Other Algae Blooms. Ubiquitous occurrence of blooms on the lower Patuxent, with May and June 2003 sampling cruises showing system-wide high chlorophyll concentrations.

Biological Monitoring of Streams

The earliest biological monitoring by DNR of streams in Calvert County's portion of the Lower Patuxent River watershed was conducted in the early 1990s. As reported in the table below, two nontidal steams were assessed using the rapid bio-assessment technique which was widely used in Maryland at the time. Sampling site locations are shown on Map 4 Monitoring Stations.

An important component of biological monitoring in nontidal stream is assessment of benthic macroinvertebrates. The value of this assessment is explained in the text box Why Look at Benthos in Streams?

DNR Rapid Bio-Assessment Data Summary [22]						
Map Key	**Location**	**Sample Year**	**Benthic**	**Habitat**	**Water Quality**	**Comments**
1	Hunting Cr. at Plum Point Rd.	1990, 92, 94, 96	poor	fair	fair	Considerable storm water damage
2	Battle Creek at Rt. 506	1992, 94, 96	fair	fair/ good	fair	Cypress swamp at sampling location

Beginning in 1997, the Maryland Biological Stream Survey (MBSS) stream sampling method of random site selection and assessment was applied in the watershed. Results are presented in the table 1997 MBSS Findings and the sampling site locations referenced in the table are also shown on Map 4 Monitoring Stations. Results of MBSS assessment method are not directly comparable to the Rapid Bioassessment method but both approaches provide an indication of biological conditions in local nontidal streams.

The next scheduled sampling of local streams by MBSS is scheduled for 2004.

Considering all biological monitoring data available for Calvert County several overall findings can be stated:[16]

– The average rating for fish is poor (fish indicator score of 2.24)

– The average rating for stream bugs is poor (benthic macroinvertebrate indicator score of 2.50)

1997 MBSS Findings * Lower Patuxent River Watershed In Calvert County					
Map Key	Watershed/Stream	Station #	Score		
			Fish	Benthos	Physical
1	Fowlers Mill Branch, tributary to Hall Creek, south of Tuckers Trail	CA-S-014-134	--	1	11
2	Chew Creek upstream of Rt. 262 near Neptune Lane	CA-S-089-201	2.75	3	64
3	Unnamed tributary to Cocktown Creek, west of Carriage Lane	CA-S-198-107	2.5	3	23
4	Unnamed Tributary to Patuxent R. Deep Landing subwatershed, north of Deep Landing Road	CA-S-187-133	2.5	2	16
5	Buzzard Island Creek across Rt. 231 from Hallowing Point Park	CA-S-123-136	--	1	19
6	Battle Creek Headwaters NW of Harris Road	CA-S-210-230	--	3	--

Key for MBSS Data Table					
Index of Biotic Integrity	Ranges for Index	Very Poor	Poor	Fair	Good
Fish	1.0 (worst) to 5.0 (best)	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	4.0 - 5.0
Benthic	1.0 (worst) to 5.0 (best)	1.0 - 1.9	2.0 - 2.9	3.0 - 3.9	4.0 - 5.0
Physical Habitat	0 (worst) to 100 (best)	0 - 11.9	12 - 41.9	42 - 71.9	72 - 100

Why Look at Benthos in Streams?

Unimpaired natural streams may support a great diversity of species like bacteria, algae, invertebrates like crayfish and insects to fish, birds, reptiles and mammals. All these groups of organisms have been extensively assessed relative to water quality and habitat quality. One group, benthic invertebrates, was found to serve as a good indicator of stream condition including water quality and habitat quality.

Benthic invertebrates are sometimes called "stream bugs" though that name overly simplifies the diverse membership of this group. This group includes mayflies, caddisflies, crayfish, etc., that inhabit the stream bottom, its sediments, organic debris and live on plant life (macrophytes) within the stream. Benthic macro-invertebrates are an important component of a stream's ecosystem.

The food web in streams relies significantly on benthic organisms. 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.

Assessment of benthic organisms is a valuable tool for stream evaluation. This group of species has been extensively used in water quality assessment, in evaluating biological conditions of streams and in gauging influences on streams by surrounding lands. These organisms 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.

Oysters

One of the commitments made in the 2000 Chesapeake Bay Agreement states that "by 2010, achieve a tenfold increase in native oysters in the Chesapeake Bay." To help gauge the opportunities for oyster management and restoration within the WRAS project area, it is valuable to gauge the local status oysters.

Oyster bars are areas defined by law to protect and control oyster habitat and populations of oysters. Legally-defined oyster bars are depicted on charts maintained by DNR. In the Patuxent River, charted oyster bars cover about 10,045 acres as shown in Map 18 Oysters. The large legal oyster bar shown on the map immediately east of Drum Point just outside of the Patuxent River mouth covers approximately an additional 5,121 acres. The boundaries of the legal oyster bars shown in the map were delineated in 1983. They are larger than any oyster habitat or populations that they may contain. Regulations control activities in and around the oyster bars. For example, regulations prohibit digging for clams in areas labeled on the chart as oyster bars or within 150 feet of an oyster bar. Protection of oyster bars is considered in the review of proposed projects like dredging and marina construction or expansion before permits are issued.

The current-day oyster lease areas in the Patuxent River cover about 10,046 acres of river bottom. The large lease area immediately east of Drum Point just outside of the Patuxent River mouth covers 5,121 about acres. The map indicates that the legal oyster bars in the Patuxent River are essentially all leased.

The map also shows that current day Patuxent River legal oyster bars are located approximately where they were 90 years ago according to a survey of oyster beds by C.C. Yates conducted between 1906 and 1912. The area covered by the historical natural oyster bars in the Patuxent River cover about 5,661 acres as shown in the map. The historical natural oyster bars shown on the east of Drum Point cover approximately an additional 3,959 acres. Because the historic oyster bars are an estimate of actual oyster beds and the current legal oyster bars are actually larger than the physical oyster bed that they contain, the information presented here does portray the change in oyster bar size over time. However, Maryland's oyster recover program, conducted by the Department of Natural Resources, invested many years replenishing existing oyster beds and creating new oyster bed areas.

Oyster populations in the Patuxent River are a small fraction of historic populations. The decline in oyster populations during the 20th Century can be traced to several causes including disease that kills a significant percentage of oysters in the Patuxent, sedimentation that covers oyster beds and water quality problems like low dissolved oxygen in parts of the river.

Sensitive Species

Sensitive species are generally recognized as being the plants or animals that are most at risk in regards to their ability to maintain healthy population levels. The most widely known are perhaps the State and Federally-listed Endangered or Threatened animals such as the bald eagle and Delmarva fox squirrel. In addition to charismatic animals such as these however, both the United States Fish and Wildlife Service and the Maryland DNR work through their respective Federal and State programs to protect a wide variety of declining non-game animals, rare plants, and the unique natural communities that support them.

For the purposes of watershed restoration, it is valuable to account for the known locations and areas of potential habitat for sensitive species in a given area. They are often indicators, and sometimes important constituents, of the network of natural areas which form the foundation for many essential natural watershed processes. In fact, in addition to conserving biodiversity in general, protecting these species and/or promoting expansion of their habitats can be an effective component for a watershed restoration program.

1. Habitat Conservation Measures

DNR's Wildlife and Heritage Service identifies important areas for sensitive species conservation in different ways. The geographic delineations most commonly used are described in the text box Marylands Sensitive Species Conservation Areas. As shown in Map 19 Sensitive Species, two of the three sensitive species overlays used by the State of Maryland are found in Calvert County's portion of the Lower Patuxent River Watershed. The purpose of utilizing these delineations is to help protect sensitive species by identifying the areas in which they are known to occur. Doing so allows DNR to work toward the conservation of these sensitive resources by evaluating potential impacts of proposed actions that may affect them. Specifically, working within an established procedural framework, the Wildlife and Heritage Service reviews projects and provides recommendations for activities falling within these overlays.

The geographic areas covered by these overlays serve as course filters. To allow for uncertainty in interpretation, the polygons on the map to depict these locations include buffer areas. Accurate on the ground information regarding species locations and habitat delineations for a specific area can be obtained from DNR's Natural Heritage Program. It is also important to note that outside of the Chesapeake Bay Critical Area, DNR generally only places requirements on projects requiring a permit/approval or those which are utilizing State funds. However, there are more broadly applied State and Federal laws and regulations which address "takings" of listed species. In addition, many counties have incorporated safeguards for areas associated with sensitive species into their project and permit review processes as well as adopting specific ordinances in some cases to protect them. In all instances, property owners are encouraged to seek advice on protecting the sensitive species / habitat within their ownership.

2. Rare, Threatened and Endangered Species List

The table Sensitive Species lists rare, threatened and endangered species found in the watershed. In general, these species are located within the areas shown on the map as Ecologically Sensitive Area (ESA).

Sensitive Species Protection Areas In the Lower Patuxent Watershed

Ecologically Sensitive Area (ESA)

Nearly 20 ESAs are identified in the Lower Patuxent River Watershed as shown in Map 19 Sensitive Species. Each ESA contains one or more sensitive species habitats. However, the entire ESA is not considered sensitive habitat. The ESA 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.

Natural Heritage Area (NHA)

No NHAs are located in the Lower Patuxent Watershed. In general, NHAs have been designated as such because they represent rare ecological communities. These are areas which provide important sensitive species habitat. They are designated in State regulation (COMAR 08.03.08.10) and are afforded specific protections in the Critical Area Law criteria. For proposed projects that could potential affect a particular NHA, recommendations and/or requirements may be put in place during the permit or approval process. These would be specifically aimed at protecting the ecological integrity of the NHA itself. To help ensure that proposed projects which may affect a given NHA are adequately reviewed, an ESA is always designated to encompass each NHA and the area surrounding it.

Wetlands of Special State Concern (WSSC)

At least three areas of WSSCs, totaling about 218 acres, are designated in the Lower Patuxent Watershed as shown on Map 19 Sensitive Species: One large area encompassing about 192 acres is located along Battle Creek including the Battle Creek Cyprus Swamp. These selected wetlands, which generally represent the best examples of Maryland's nontidal wetland habitats, are afforded additional protection in state law beyond the permitting requirements that apply to wetlands generally. The Maryland Department of the Environment may be contacted for more information regarding these regulations. To help ensure that proposed projects that may affect a WSSC are adequately reviewed, an ESA 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

Sensitive Species Tracked by Maryland in the Lower Patuxent River Watershed			
	Scientific Name	**Common Name**	**Status***
Animals	Cicindela dorsalis dorsal	Northeastern beach tiger beetle	E
	Falco peregrinus anatum	American peregrine falcon	E
	Haliaeetus leucocephalus	Bald eagle	T
Plants	Aeschynomene virginica	Sensitive joint-vetch	E
	Antennaria solitaria	Single-headed pussytoes	T
	Aristida lanosa	Woolly three-awn	E
	Aster concolor	Silvery aster	E
	Carex mesochorea	Midland sedge	O
	Centrosema virginianum	Spurred butterfly-pea	O
	Gymnopogon brevifolius	Broad-leaved beardgrass	E
	Hermeuptychia sosybius	Carolina satyr	O
	Matelea carolinensis	Anglepod	E
	Myosotis macrosperma	Large-seeded forget-me-not	O
	Parnassia asarifolia	Kidneyleaf grass-of-parnassus	E
	Potamogeton foliosus	Leafy pondweed	E
	Potamogeton perfoliatus	Clasping-leaved pondweed	O
	Potamogeton spirillus	Spiral pondweed	O
	Rhynchosia tomentosa	Hairy snoutbean	T
	Sagittaria engelmanniana	Engelmann's arrowhead	T
	Sagittaria longirostra	Long-beaked arrowhead	O
	Solidago speciosa	Showy goldenrod	T
	Sporobolus clandestinus	Rough rushgrass	E
* Key for Maryland Status. E-endangered, T-threatened, O-Other			

Submerged Aquatic Vegetation

The well-defined link between water quality and submerged aquatic vegetation (SAV) distribution/abundance make SAV communities good barometers of the health of estuarine ecosystems. SAV is not only important as an indicator of water quality, but it 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 in adjacent unvegetated areas. Additionally, several species of waterfowl depend on SAV for food when they over-winter in the Chesapeake region.

In recognition of the importance of SAV as a key component of the Bay environment, the Chesapeake Executive Council on December 9, 2003 adopted 185,000 acres as a goal for Baywide SAV restoration strategy. This is more than double the 89,658 acres of SAV that was identified in 2003.[23]

1. Area of SAV Beds

Between 1984 and 1999, SAV location and extent in the Lower Patuxent River has varied significantly as the table SAV Distribution And Acreage and Map 20 SAV indicate. Maps of SAV locations can be created interactively on DNR's Internet site MERLIN at www.mdmerlin.net. Several summary findings can be drawn from this information:

– Total SAV bed acreage in the Lower Patuxent River was sometimes over 100 acres in the mid 1980s and the late 1990s based on interpretation of aerial photography. However, no SAV could be identified in aerial photographs in the early 1990s.
– Typical locations of SAV beds in the mid 1980s tended to be in areas downstream of Brooms Island. Following the disappearance of SAV in the early 1990s, SAV beds that reappeared tended to be in areas upstream of Cocktown Creek.
– The reasons for the variations listed above are not well understood. Part of the variation may be associated with rainfall (wet/dry years) and the differences in nutrient loads entering the Lower Patuxent River from nonpoint sources and point sources over time.

2. SAV Area Relative Change in Nutrient Loads[17]

Drawing on many years of water quality monitoring data from the Patuxent River, concentrations of nutrients in the open water of the mainstem are documented for several decades. Nutrient load increases were documented from the 1960s through the 1980s and nutrient load reductions were documented thereafter

In research slated to be published in late 2003, the relationship between Patuxent nutrient loads and the extent of SAV is to be explored. The research is anticipated to qualitatively show that decreasing SAV area coincides with increasing nutrient loads. However, as nutrient loads decreased, Patuxent SAV have not shown a similar rebound.

SAV Distribution And Acreage – Lower Patuxent River													
Year	General Location* Of SAV Beds And Their Acreage In That Location » » Patuxent Mainstem Downstream | Patuxent Mainstem Upstream º º												Total
	1	2	2a	3	3a	4	5	6	7	8	9	10	
1999	16												16
1998									8	1	34	79	122
1997		3									30	84	117
1996									5		26	70	101
1995											34	51	85
1994											33	31	64
1993	2												2
1992													0
1991													0
1990													0
1989	7			1									8
1988 - no data													
1987		21		25		36		7					89
1986		1				9		22					32
1985	21	28		70		11							130
1984			9		10		16						35

* KEY for Locations along Patuxent River Mainstem

1- Solomons Harbor vicinity
2- Hellen Creek vicinity
    2a- In Hellen Creek
3- St. Leonards Creek vicinity
    3a- In St. Leonards Creek
4- Island Creek vicinity

5- Battle Creek vicinity
6- Buzzard Island Creek vicinity
7- Cocktown Creek vicinity
8- Chew Creek vicinity
9- Graham & Friday Creek vicinity
10- Hall Creek vicinity

RESTORATION AND CONSERVATION TARGETING

There are a number of programs and tools available to assist in implementing goals for protection of valued watershed resources and for targeting restoration of those that have become degraded or otherwise function less than optimally.

2003 Stream Assessments Conducted By DNR

During 2003 in partnership with Calvert County, DNR conducted two types of assessment of selected streams in Calvert County's portion of the Lower Patuxent River watershed. The reports are available at www.dnr.maryland.gov/watersheds/surf/proj/wras.html.

A Stream Corridor Assessment focused on several subwatersheds selected by Calvert County. DNR uses trained teams who walk up to about 100 miles of streams to document potential problems and restoration opportunities. The kinds of issues identified include: channel alteration, erosion sites, exposed pipes, fish barriers, inadequate buffers, livestock in the stream, near-stream construction, pipe outfalls, unusual conditions, and reference conditions which are cataloged at regular intervals as a way to define typical stream conditions.

In the Synoptic Survey and Aquatic Community Assessment, DNR staff collected water quality samples and assessed fish and benthic macroinvertebrates in selected nontidal streams. The water quality findings in the report can help identify problem areas and relative conditions among local streams based on measurements of dissolved oxygen, pH, nutrients (phosphorus and nitrogen), conductivity and flow. The nutrient yields estimated at each sampling site allow ranking the subwatersheds based on the nutrient load estimates. For some of these nontidal stream sampling sites, DNR staff has also assessed fish and benthic organism populations. These assessments provide additional perspectives to gauge local water quality and habitat conditions.

Agricultural Conservation Programs

Many farmers in Calvert County willingly implement management systems that address nutrient runoff and infiltration, erosion and sediment control, and animal waste utilization. Some of the best management practices identified in Soil Conservation and Water Quality Plans for implementation on individual farms include 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 Calvert SCD and Natural Resource Conservation Service (NRCS). [28]

Marina Programs

Marina Status Lower Patuxent River	Calvert County	Other Countie s
Clean Marina Participant (has pumpout available)	1	--
Marina Offering Pumpout	13	4
Other Marinas	15	11

Discharges of sewage from boats are a concern for water quality because they release nutrients, biochemical oxygen demand and pathogens. These discharges are preventable if a sufficient number of pumpout facilities are locally available and boat operators take advantage of these services. Boat maintenance and operation also can contribute petroleum and other noxious materials to the aquatic environment. The status of marinas in the Lower Patuxent River is summarized in the adjacent table and their approximate location is shown in Map 21 Marinas.

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.maryland.gov/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.

Stream Buffer Restoration

1. Riparian Forest Buffer Goal

In December 2003, the Chesapeake Bay Executive Council members agreed to a five-fold expansion of the current forest buffer restoration goal. The new goal commits the Bay states and federal government to restoring 10,000 miles of riparian forest buffers along the streams and rivers that feed the Bay by 2010. In 2002, the Bay states and the federal government met the first buffer restoration goal fully eight years ahead of schedule. Approximately 2,869 miles of buffers have been restored in the Bay watershed by the end of 2003.[23]

2. Progress In Calvert County's Portion of the Lower Patuxent River Watershed

As shown on Map 22 Stream Buffer Scenario, more than 20 stream buffer plantings have been completed in Calvert County's portion of the Lower Patuxent River watershed between 1996 and the end of 2001 according to the DNR Forest Service database. Both the mapped information and the table Riparian Forest Buffer Creation Tracking are drawn from that database that focuses entirely on projects where DNR was a participant.

Riparian Forest Buffer Creation Tracking Calvert County Lower Patuxent River Watershed Forest Service Database 1996 - 2001				
Subwatershed	Location	Length (feet reported)	Av. Width (feet reported)	Acres (estimated)
Hall Creek	Hall Cr. headwaters	900	66	1.4
Friday/Graham Cr.	Friday Cr. headwaters	300	60	0.4
Cocktown Creek	Unnamed Trib	2,260	1,000	55.2
	Patuxent Mainstem	Project 1) 1,300 Project 2) 1,600	50 50	
Hunting Creek	Trib to Sewell Br.	1,760	150	14.2
	Patuxent Mainstem near mouth of Little Lyons Creek	Project 1) 200 Project 2) 900 Project 3) 400 Project 4) 400	200 50 165 110	
	Patuxent Mainstem near Gods Grace Pt.	Project 1) 200 Project 2) 1,000	300 100	
Ramsey/Caney Creek	Ramsey Creek	Project 1) 1,100 Project 2) 300	40 116	2.3
	Caney Creek	200	115	
Buzzard Is. Creek	Near Sandy Point	200	60	0.3
Battle Creek	Trib to tidal area	200	80	0.4
St. Leonards Cr.	Perrin Br. headwaters	300	60	4.5
	Unnamed trib to Patux	2,270	60	
	Patuxent mainstem	Project 1) 650 Project 2) 150 Project 3) 150	35 56 96	
Solomons Harbor	Patuxent mainstem	Project 1) 1,320 Project 2) 233 Project 3) 700	50 150 300	7.1
Total		18,993 feet (3.6 miles)		85.8

In total, the forest buffer plantings extended about 3.6 miles and covered nearly 86 acres. Plantings on publicly owned land in the vicinity of Cocktown Creek and Kings Landing accounts for 27% of the total miles reported and 64% of the total estimated acreage.

3. Benefits and General Recommendations

Natural vegetation in stream riparian zones, particularly forest, provides 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 Services and other programs like Conservation Reserve Enhancement Program (CREP), managed by the DNR Forest Service, are available to assist land owners who volunteer to explore these opportunities.

4. Headwater Stream Buffers

Headwater streams are also called first order streams. 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.

5. 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 (see table next page). By restoring naturally vegetated stream buffers adjacent to lands producing the highest pollutant loads, nutrient and sediment loads can be reduced most efficiently. Map 22 Stream Buffer Scenario focuses on the crop and pasture lands within 50 feet of a stream and identifies stream segments that lack naturally vegetated stream buffers using computer GIS. DNR encourages creating stream buffers at least 50 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.

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

6. 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 Lower Patuxent River drainage, 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:
– Plants 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 22 Stream Buffer Scenario identifies lands that are adjacent to streams that meet three criteria: hydric soil is present, the riparian area is used for crops or pasture and naturally vegetated stream buffers are absent. In these areas, restoration of stream buffers would be most likely to intercept nitrogen, control sediment and phosphorus movement, and improve stream water quality and habitat in general. Additional assessment and field evaluation should be used to determine land owner interest, the practical implications of creating naturally vegetated stream buffers in areas identified and to evaluate any hydrologic modification of these soils, such as ditching or draining activities.

7. Optimizing Water Quality Benefits by Combining Priorities

Targeting of stream buffer restoration projects may provide multiple benefits depending on many factors. To maximize multiple benefits, finding a site with a mix of attributes like those listed here could result in greater nonpoint source pollution reduction and habitat enhancement:

– 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 general, targeting restoration projects in selected tributaries or small watersheds will tend to offer the greatest probability of producing measurable water quality improvement in the short term. By selecting small areas like a small first order stream for restoration, there is greater likelihood that local water quality will improve with relatively limited investment. In addition, local water quality improvements will likely contribute to downstream improvements.

Wetland Restoration

Wetlands serve important environmental functions such as providing habitat and nursery areas for many organisms, facilitating nutrient uptake and recycling, providing erosion control. However, most watersheds in Maryland have significantly fewer wetland acres today than in the past. This loss due to draining, filling, etc., 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.

Map 23 Wetland Restoration Scenario indicates that there appears to be potential for wetland restoration based on identifying crop land and/or pasture on hydric soil. This is one of many potential scenarios for finding opportunities for wetland restoration. The steps and priorities used to generate the map are listed below:

– Data used: Hydric soils (Maryland Dept. of Planning Data), existing wetlands (DNR Wetlands), land use (Maryland Dept. of Planning, 2000).
– Identify candidate hydric soil areas based on land use. Hydric soils used in agricultural fields are selected for consideration. Hydric soils used for development or underlying natural vegetation are not considered in this scenario.
– Explore hydric soils based on land use / land cover and proximity to wetlands or streams.

The potential wetland restoration sites suggested in the scenario can be filtered further by using more accurate wetlands and soil information and by considering land ownership or other factors like like habitat enhancement opportunities, sensitive species protection, targeting specific streams or subwatersheds for intensive restoration, and using Conservation Reserve Enhancement Program (CREP) information.

PROJECTS RELATED TO THE WRAS PROCESS

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 following list 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" has not been awarded to projects in the Lower Patuxent Watershed during the 1999 through 2002 time frame.

Other Projects/Programs

This section summarizes projects and programs 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. Hall Creek Watershed Water Quality Management Plan

The focus of this 1994 plan is to an approach to reducing nutrients delivered to Hall Creek. The nutrient loads in the watershed are essential all nonpoint source. Approaches considered include agricultural BMPs retirement of highly erodible lands, urban nutrient management and stormwater management for developed lands, septic system alternatives and growth management approaches.

2. Land Use and Water Quality In Hunting Creek: Research & Outreach

This 2002 report presented results of a Calvert County project, funded by US EPA, in cooperation with the Calverton School and the University of Maryland Center for Environmental Science Institute for Ecological Economics (UOM).[20]

– Monitoring of three tributaries to Hunting Creek was conducted by Calverton students. Water quality and benthic macroinvertebrate data was collected. Water quality parameters assessed included temperature, salinity, total suspended solids, chlorophyll *a*, nitrate/nitrite, ammonia and phosphate.

– A landscape model for the Hunting Creek watershed was created by UOM to assess water quality impacts of current land use and projected build-out land use based on current zoning. For more information see http://iee.umces.edu/PLM/HUNT

– Outreach and education was achieved through a combination of hands-on experience, local cable television reporting, newspaper reporting and an Internet page.

Conclusions and recommendations developed in this work appear to be relevant for consideration in the WRAS project:

– By avoiding development in stream buffer areas most of the increase in nitrogen load increase can be reduced compared to maximum build-out scenario.
– Redesign of septic fields to deliver effluent to the root zone, rather than groundwater, can increase nitrogen retention and improve water quality in estuaries.
– Selected land use practices on developed areas like using trees or natural vegetation instead of lawns.
– Additional research is recommended to better quantify local contribution of nitrogen relative to atmospheric deposition arising from distant sources.

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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.
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.
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.

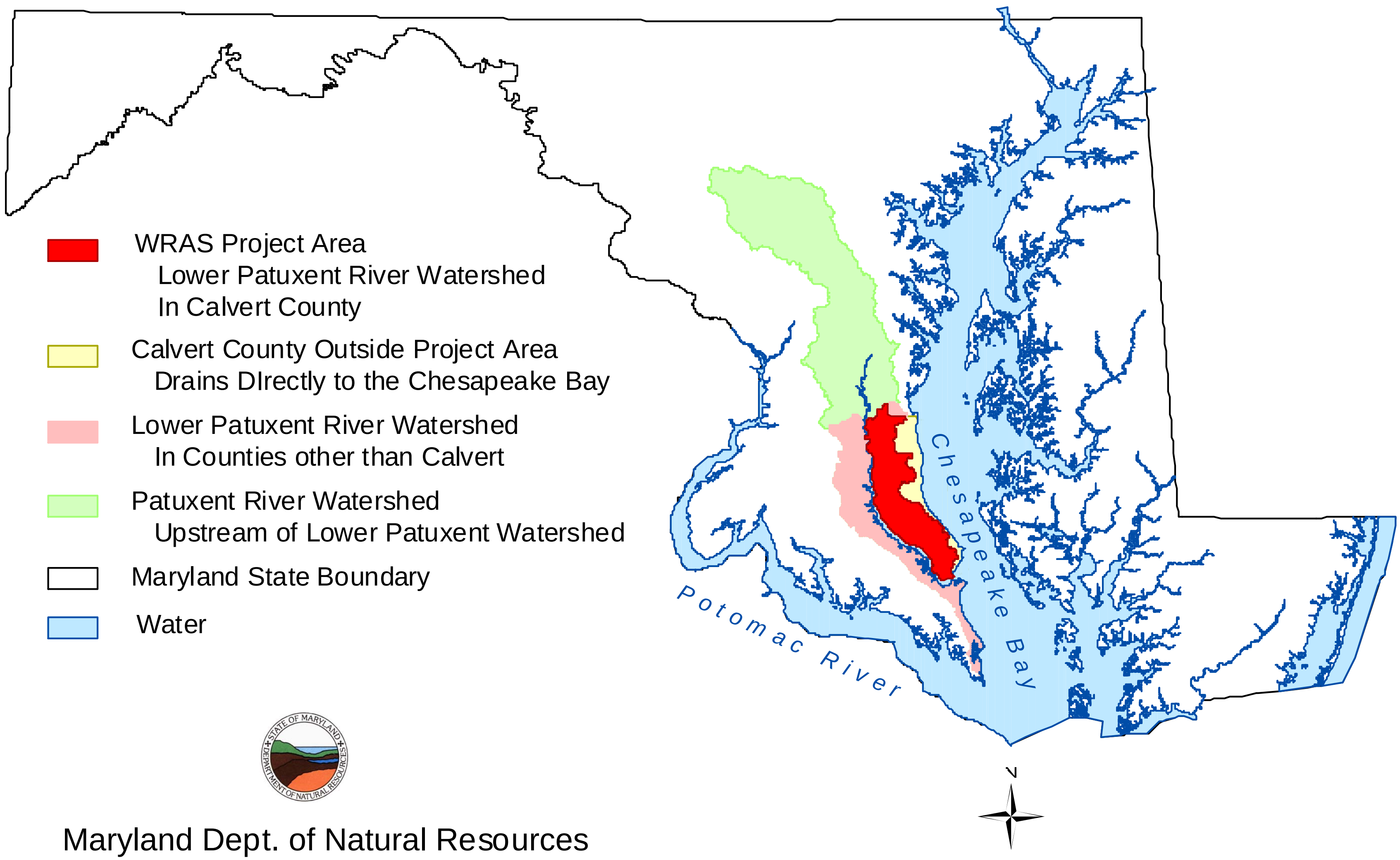
CRP	Conservation Reserve Program, a program of Farm Service Agency in cooperation with local Soil Conservation Districts. CRP encourages farmers to take highly erodible and other environmentally-sensitive farm land out of production for ten to fifteen years.
CWAP	Clean Water Action Plan, promulgated 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)
ESA	Ecologically Significant 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.
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 DNR Watershed Services 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.
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 macroinvertebrate 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 Location
WRAS Project Area: Lower Patuxent River In Calvert County



0 12.5 25 50 75 100 Miles

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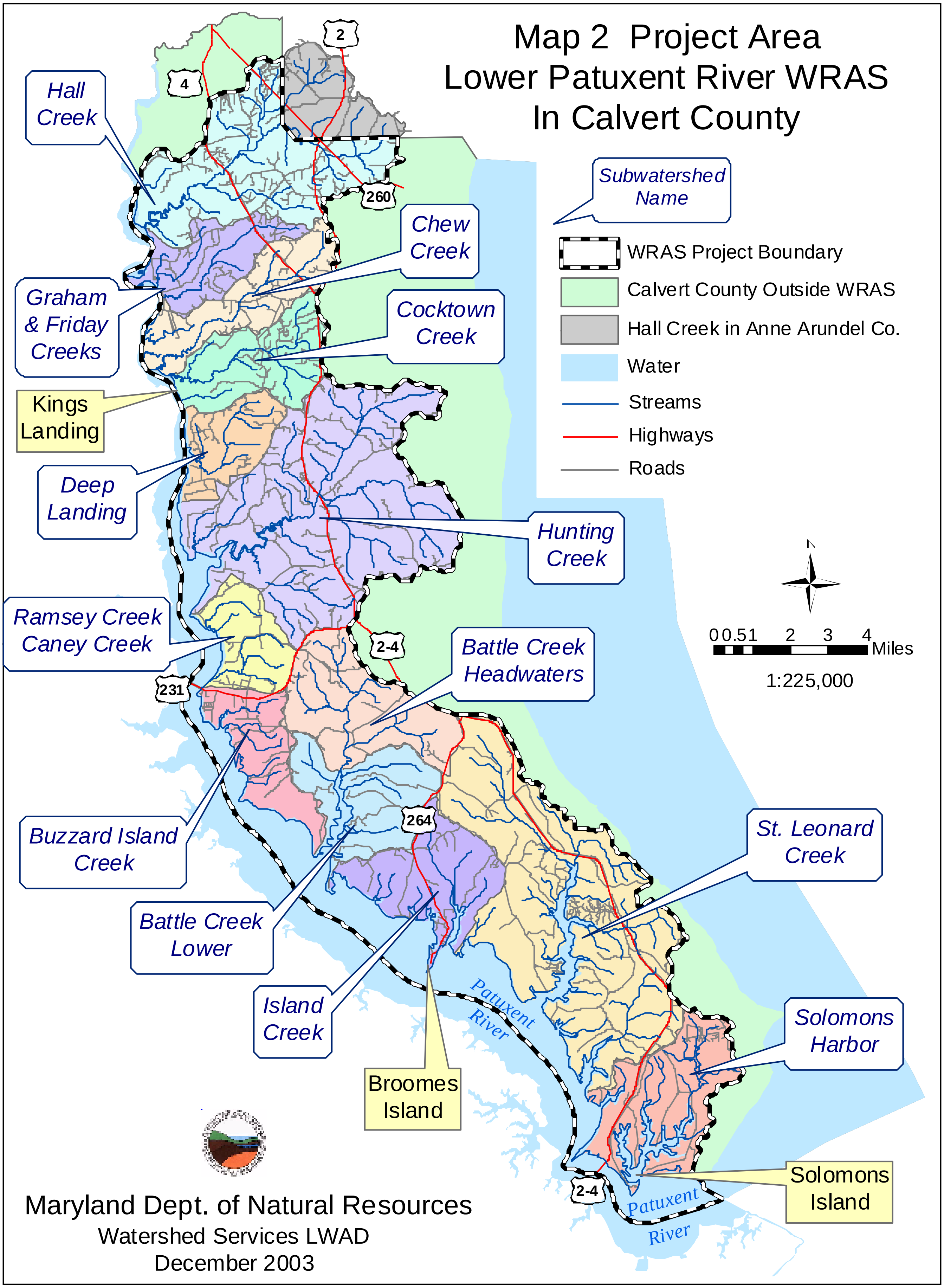
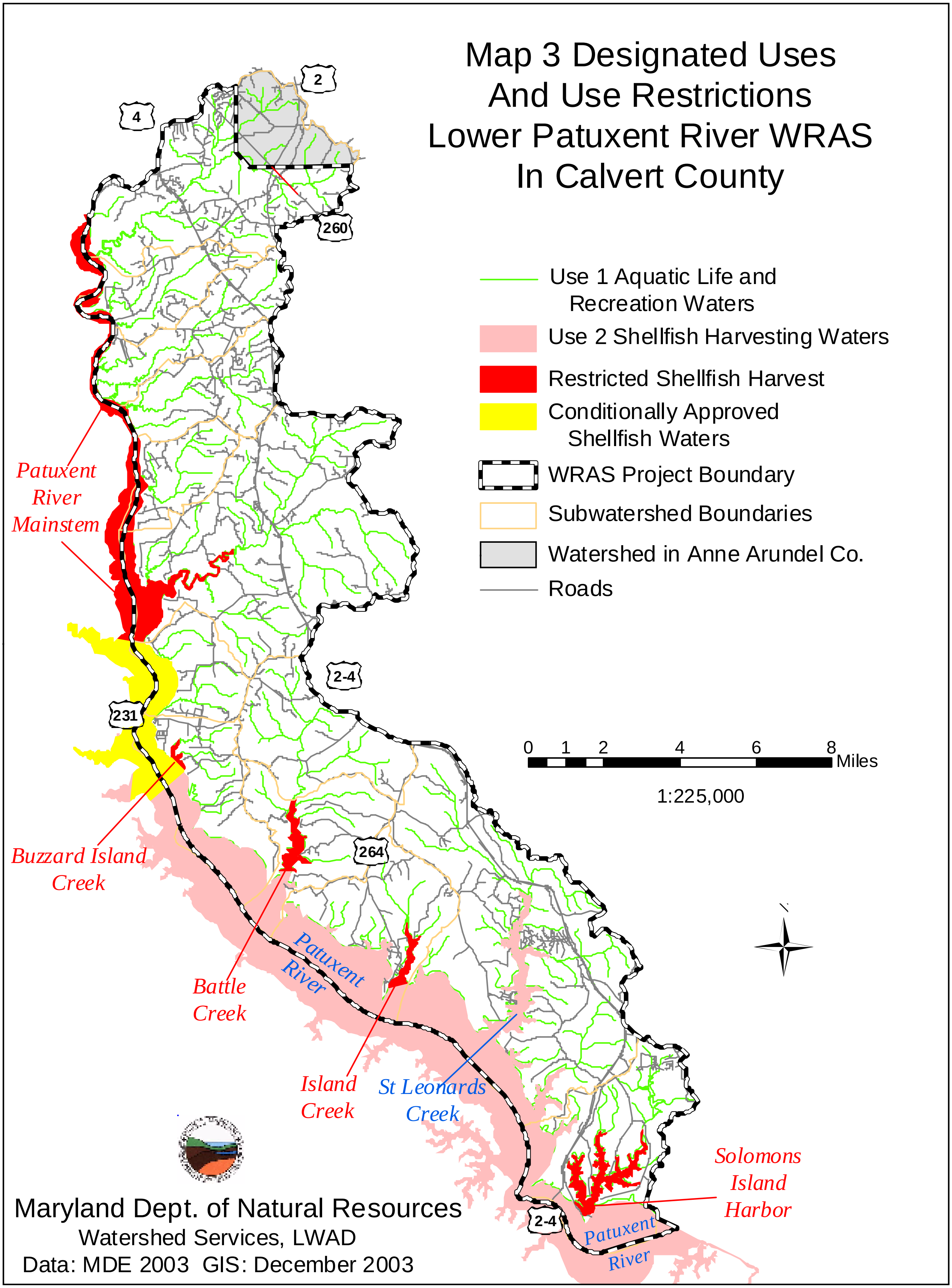
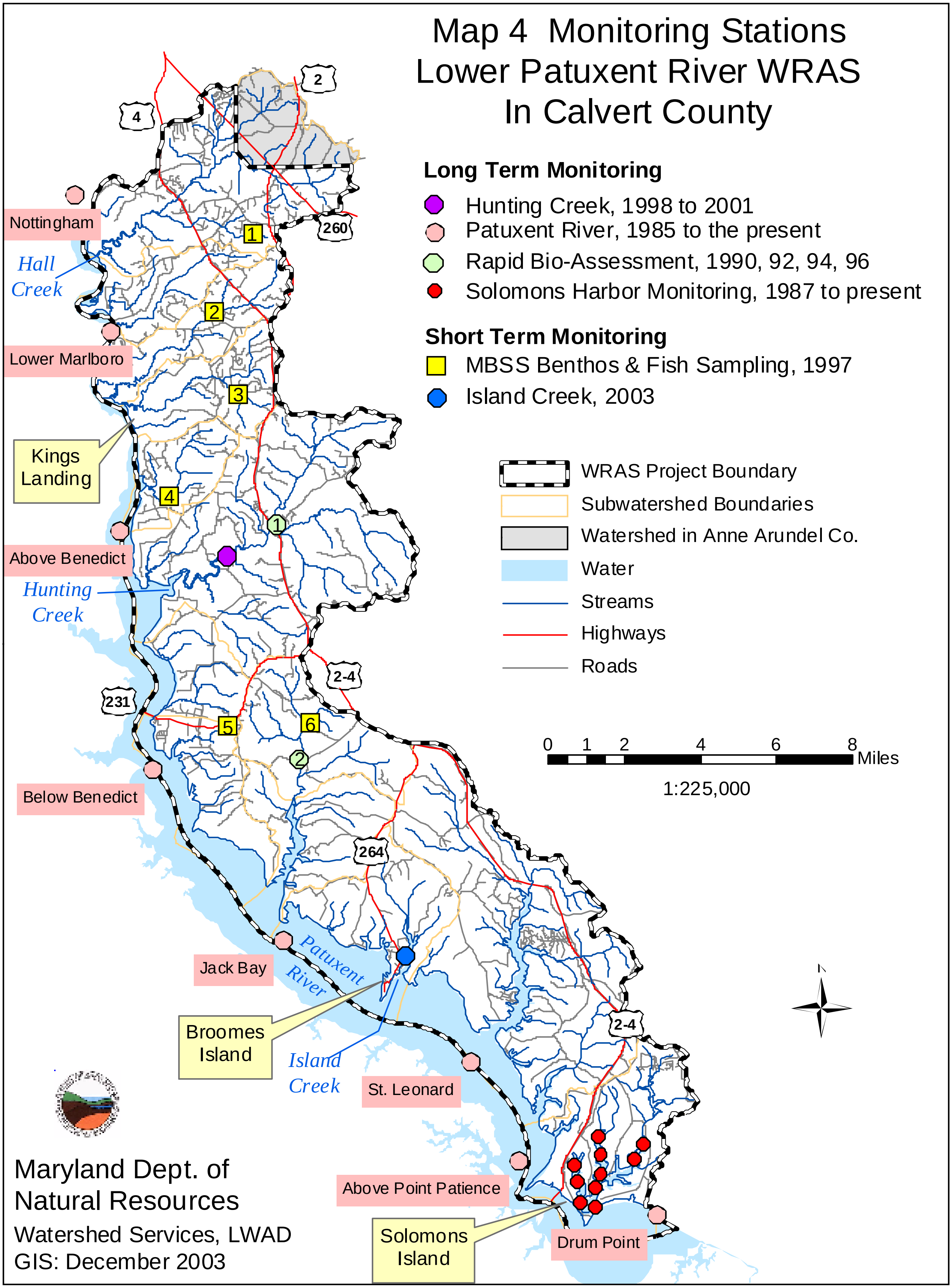
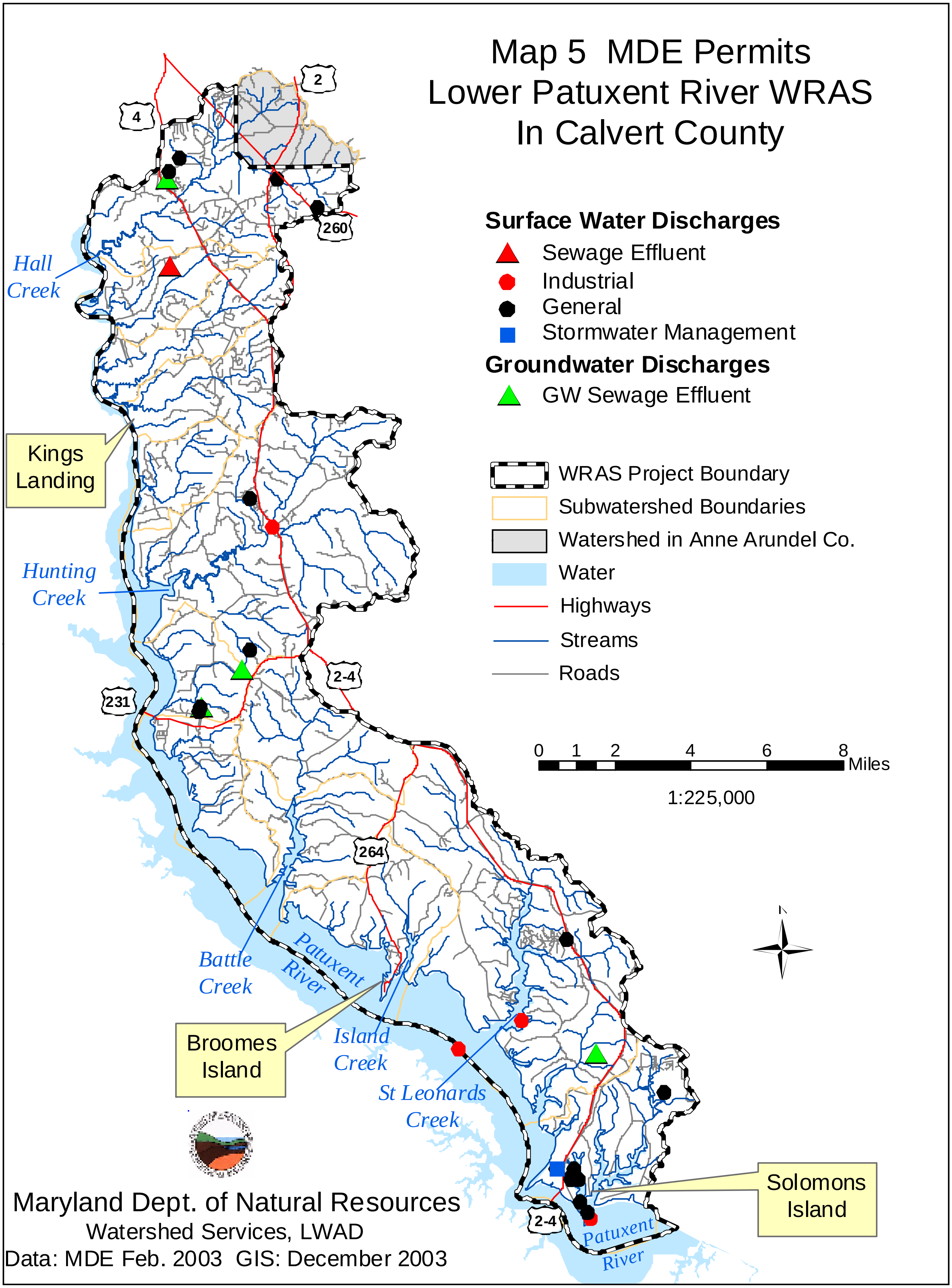
Maryland Dept. of Natural Resources
Watershed Services
Landscape and Watershed Analysis Division
December 2003

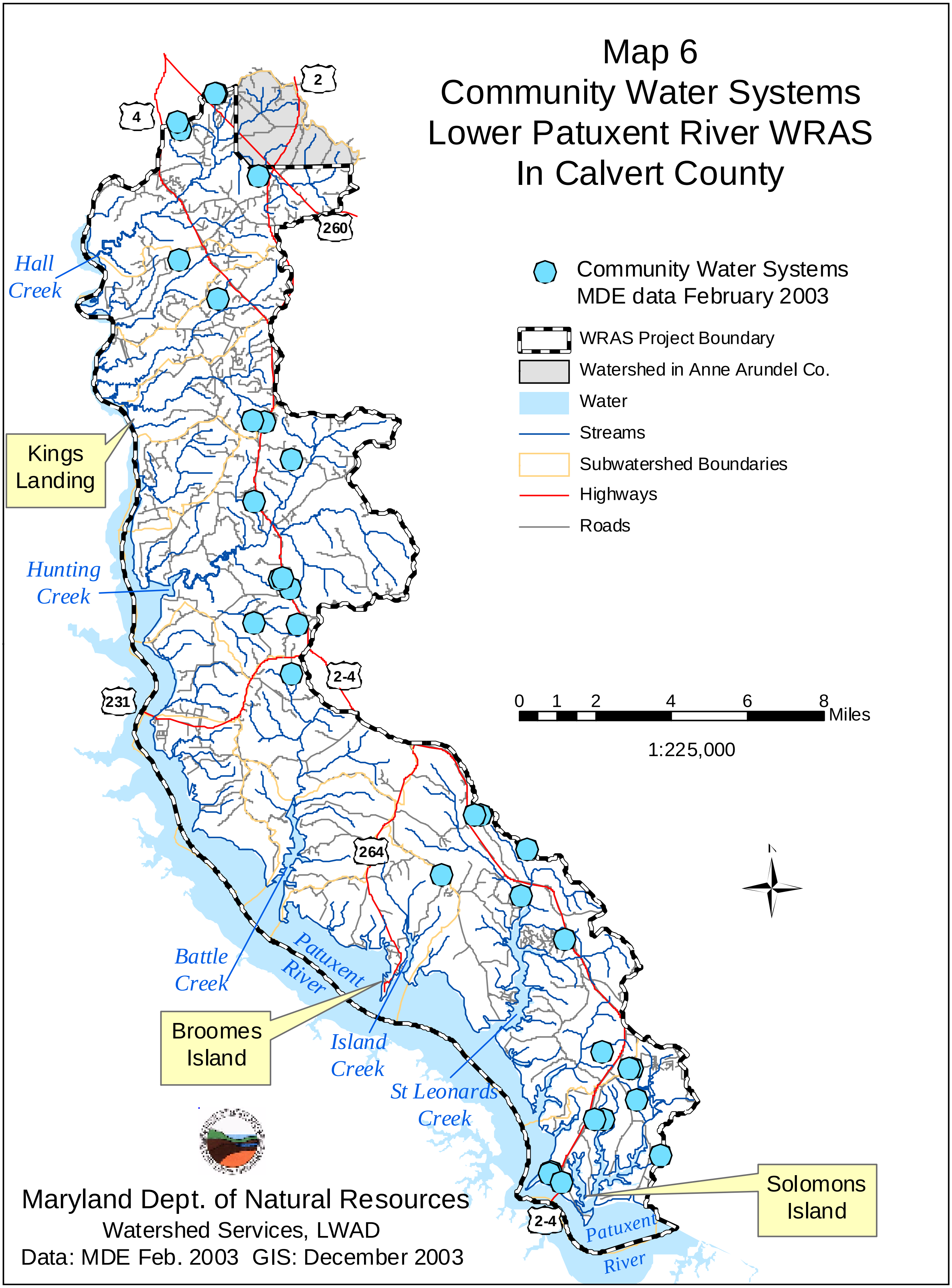

Map 2 Project Area
Lower Patuxent River WRAS
In Calvert County
Subwatershed Name
WRAS Project Boundary
Calvert County Outside WRAS
Hall Creek in Anne Arundel Co.
Water
Streams
Highways
Roads
Hall Creek
Chew Creek
Graham & Friday Creeks
Cocktown Creek
Kings Landing
Deep Landing
Hunting Creek
Ramsey Creek Caney Creek
Battle Creek Headwaters
Buzzard Island Creek
Battle Creek Lower
Island Creek
Broomes Island
St. Leonard Creek
Solomons Harbor
Solomons Island
Patuxent River
Patuxent River
2
4
260
2-4
231
264
2-4
0 0.5 1 2 3 4 Miles
1:225,000
Maryland Dept. of Natural Resources
Watershed Services LWAD
December 2003


Map 3 Designated Uses
And Use Restrictions
Lower Patuxent River WRAS
In Calvert County
Use 1 Aquatic Life and Recreation Waters
Use 2 Shellfish Harvesting Waters
Restricted Shellfish Harvest
Conditionally Approved Shellfish Waters
WRAS Project Boundary
Subwatershed Boundaries
Watershed in Anne Arundel Co.
Roads
0 1 2 4 6 8 Miles
1:225,000
2
4
260
2-4
231
264
2-4
Patuxent River Mainstem
Buzzard Island Creek
Battle Creek
Patuxent River
Island Creek
St Leonards Creek
Solomons Island Harbor
Patuxent River
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDE 2003 GIS: December 2003

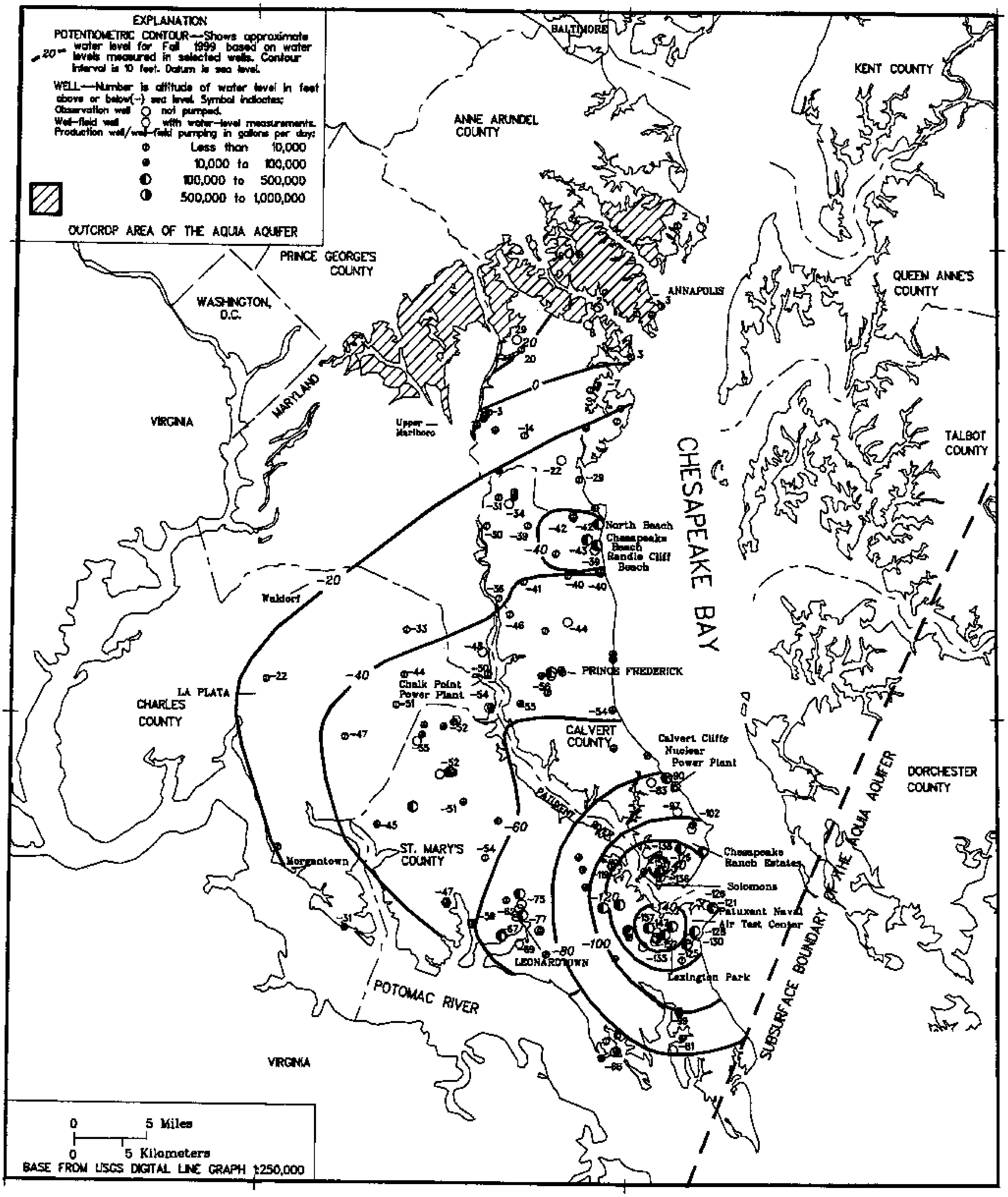


Map 4 Monitoring Stations
Lower Patuxent River WRAS
In Calvert County
Long Term Monitoring
Hunting Creek, 1998 to 2001
Patuxent River, 1985 to the present
Rapid Bio-Assessment, 1990, 92, 94, 96
Solomons Harbor Monitoring, 1987 to present
Short Term Monitoring
MBSS Benthos & Fish Sampling, 1997
Island Creek, 2003
WRAS Project Boundary
Subwatershed Boundaries
Watershed in Anne Arundel Co.
Water
Streams
Highways
Roads
0 1 2 4 6 8 Miles
1:225,000
2
4
260
2-4
231
264
1
2
3
4
5
6
Nottingham
Hall Creek
Lower Marlboro
Kings Landing
Above Benedict
Hunting Creek
Below Benedict
Jack Bay
Patuxent River
Broomes Island
Island Creek
St. Leonard
Above Point Patience
Solomons Island
Drum Point
Maryland Dept. of Natural Resources
Watershed Services, LWAD
GIS: December 2003

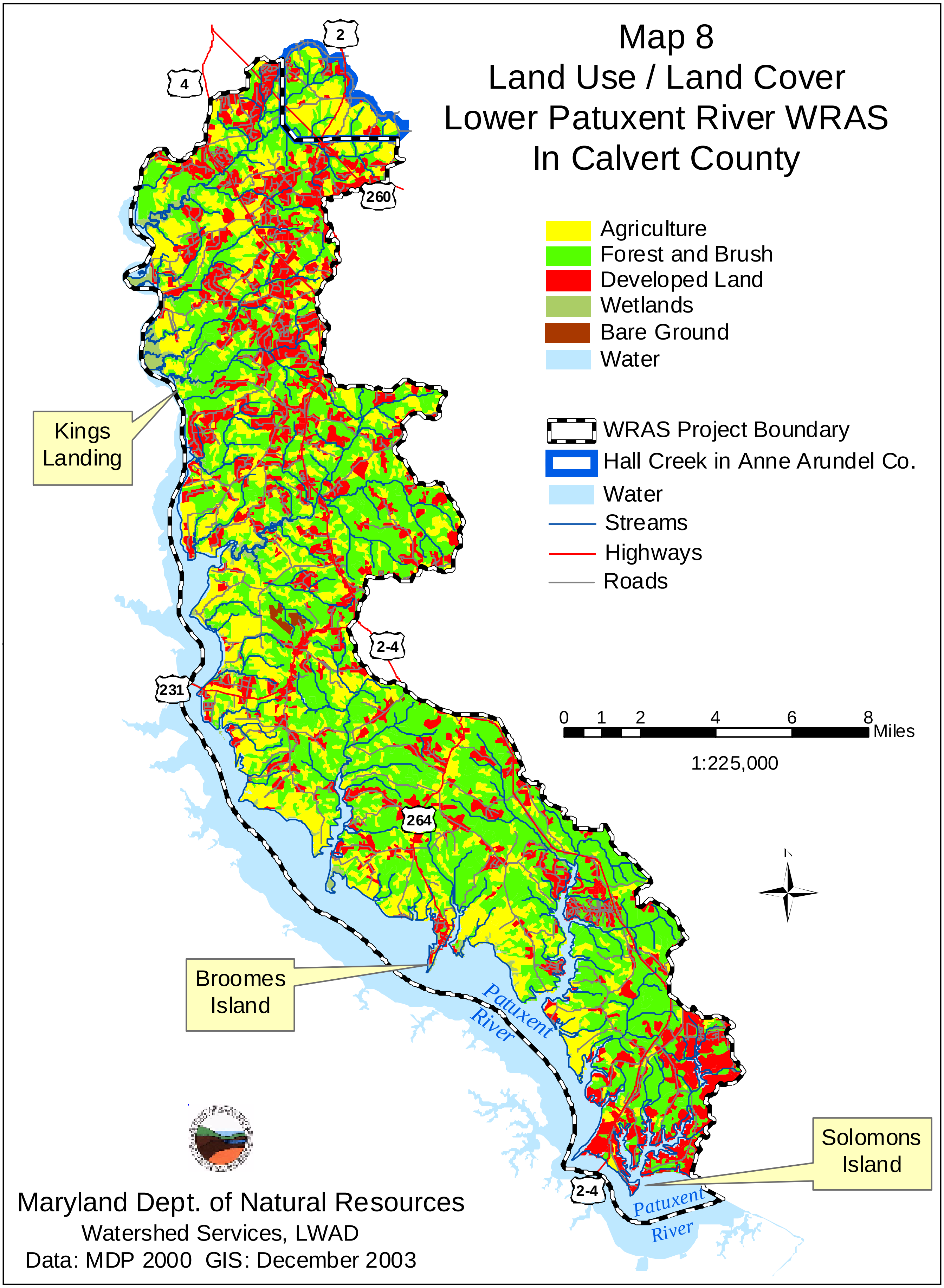

Map 5 MDE Permits
Lower Patuxent River WRAS
In Calvert County
Surface Water Discharges
Sewage Effluent
Industrial
General
Stormwater Management
Groundwater Discharges
GW Sewage Effluent
WRAS Project Boundary
Subwatershed Boundaries
Watershed in Anne Arundel Co.
Water
Highways
Streams
Roads
0 1 2 4 6 8 Miles
1:225,000
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
Patuxent River
4
2
260
2-4
231
264
2-4
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDE Feb. 2003 GIS: December 2003


Map 6
Community Water Systems
Lower Patuxent River WRAS
In Calvert County
Community Water Systems
MDE data February 2003
WRAS Project Boundary
Watershed in Anne Arundel Co.
Water
Streams
Subwatershed Boundaries
Highways
Roads
0 1 2 4 6 8
Miles
1:225,000
2
4
260
2-4
231
264
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDE Feb. 2003 GIS: December 2003

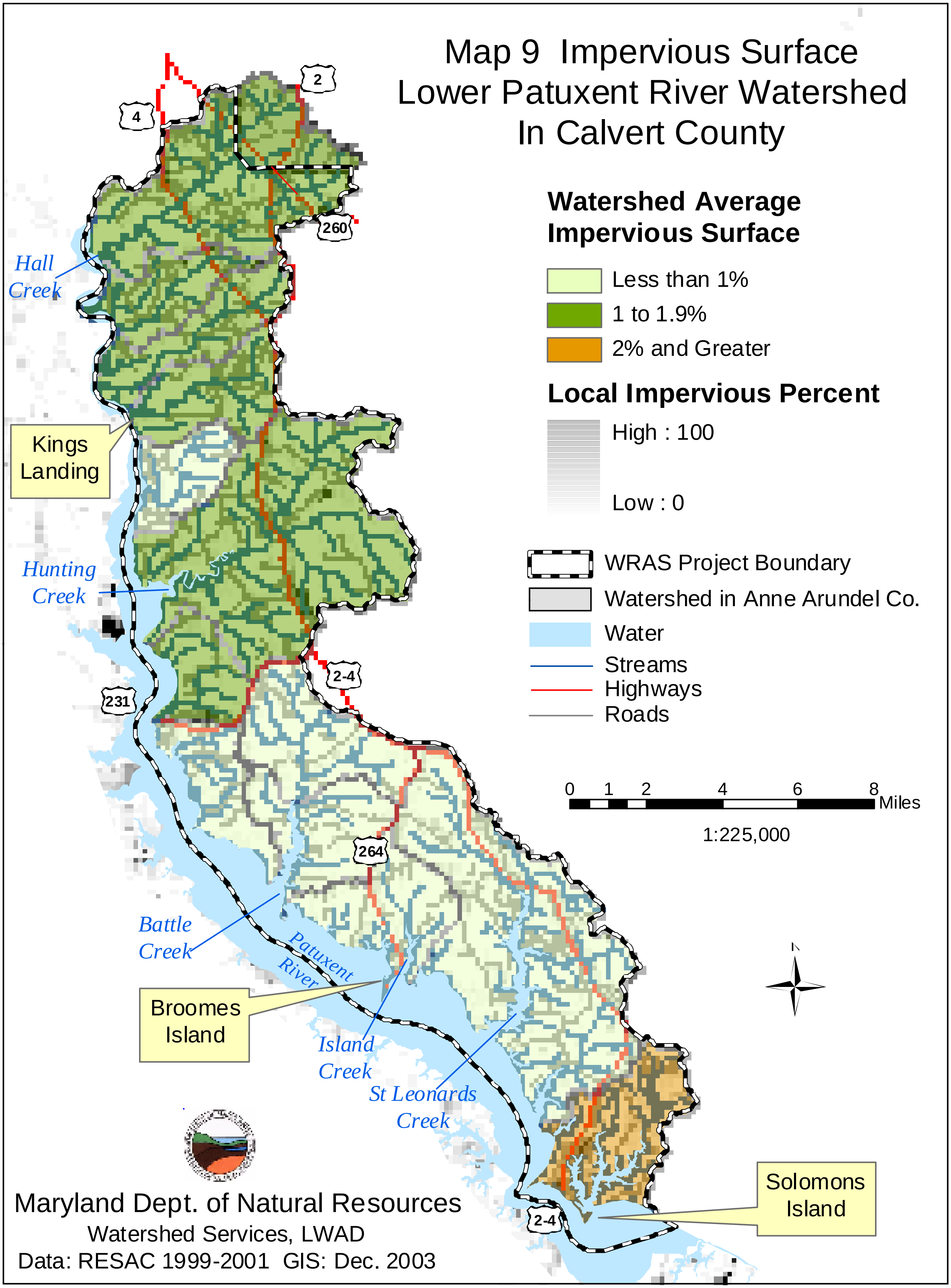
Map 7 Aquia Aquifer
Potentiometric Surface For Fall 1999

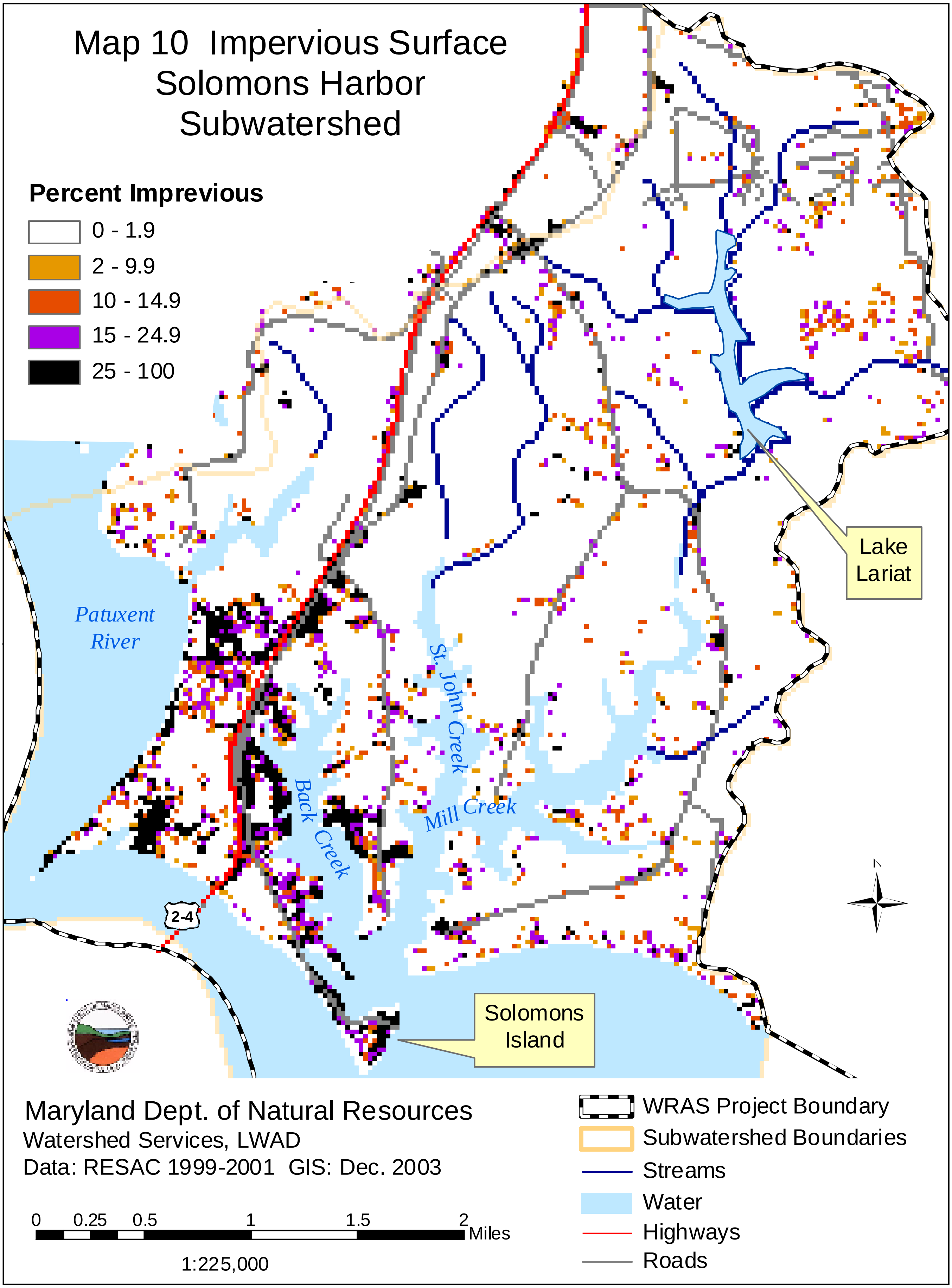


Adapted from Maryland Geological Survey Report No. S1/RI 64. 2001. Page 22.



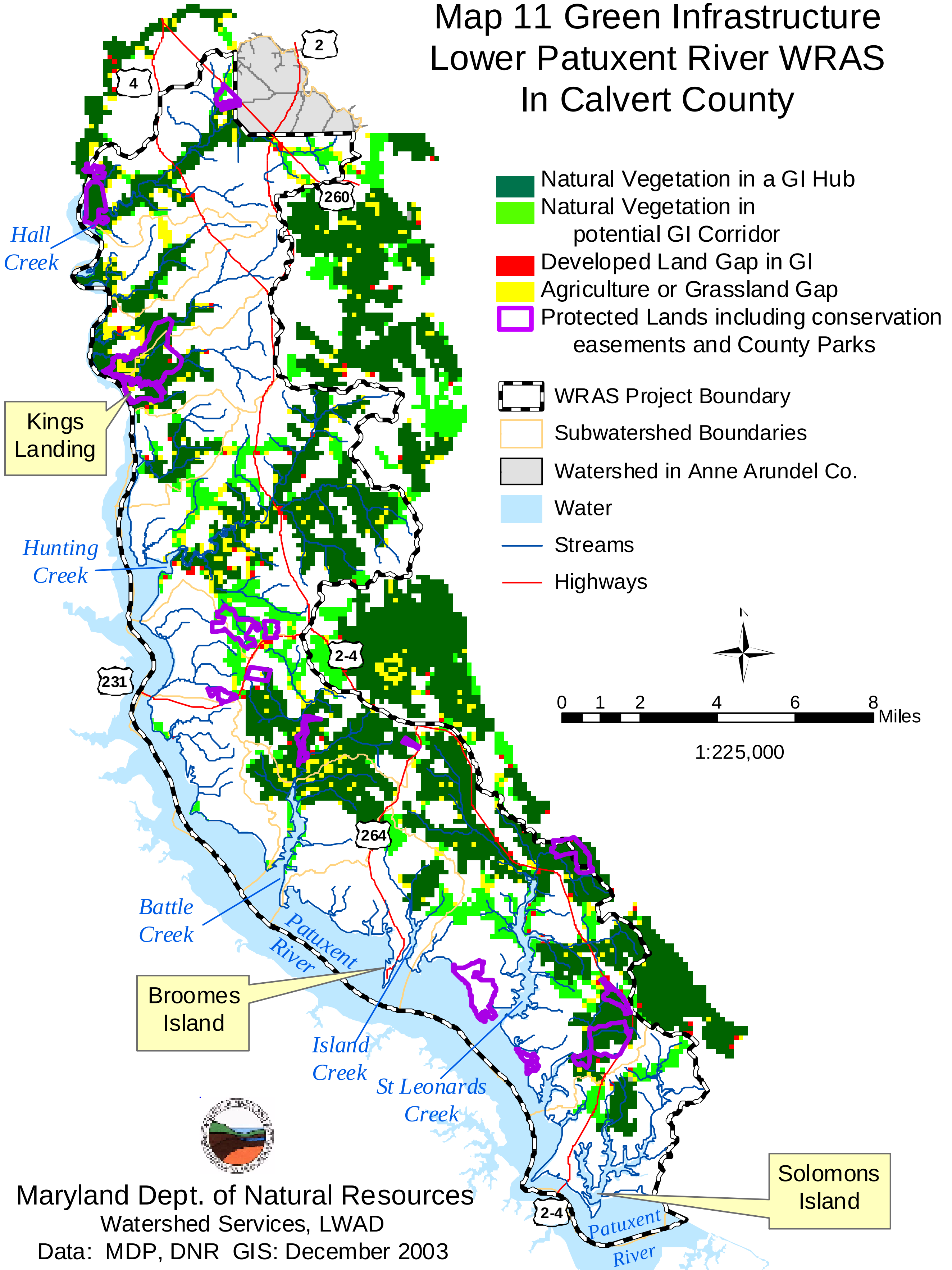
Map 8
Land Use / Land Cover
Lower Patuxent River WRAS
In Calvert County
Agriculture
Forest and Brush
Developed Land
Wetlands
Bare Ground
Water
WRAS Project Boundary
Hall Creek in Anne Arundel Co.
Water
Streams
Highways
Roads
0 1 2 4 6 8 Miles
1:225,000
2
4
260
2-4
231
264
Kings Landing
Broomes Island
Solomons Island
Patuxent River
Patuxent River
2-4
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP 2000 GIS: December 2003


Map 9 Impervious Surface
Lower Patuxent River Watershed
In Calvert County
Watershed Average Impervious Surface
Less than 1%
1 to 1.9%
2% and Greater
Local Impervious Percent
High : 100
Low : 0
WRAS Project Boundary
Watershed in Anne Arundel Co.
Water
Streams
Highways
Roads
0 1 2 4 6 8 Miles
1:225,000
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
4
2
260
2-4
231
264
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: RESAC 1999-2001 GIS: Dec. 2003



Map 10 Impervious Surface
Solomons Harbor
Subwatershed
Percent Imprevious
0 - 1.9
2 - 9.9
10 - 14.9
15 - 24.9
25 - 100
Patuxent River
St. John Creek
Back Creek
Mill Creek
Lake Lariat
Solomons Island
2-4
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: RESAC 1999-2001 GIS: Dec. 2003
0 0.25 0.5 1 1.5 2 Miles
1:225,000
WRAS Project Boundary
Subwatershed Boundaries
Streams
Water
Highways
Roads

Map 11 Green Infrastructure
Lower Patuxent River WRAS
In Calvert County



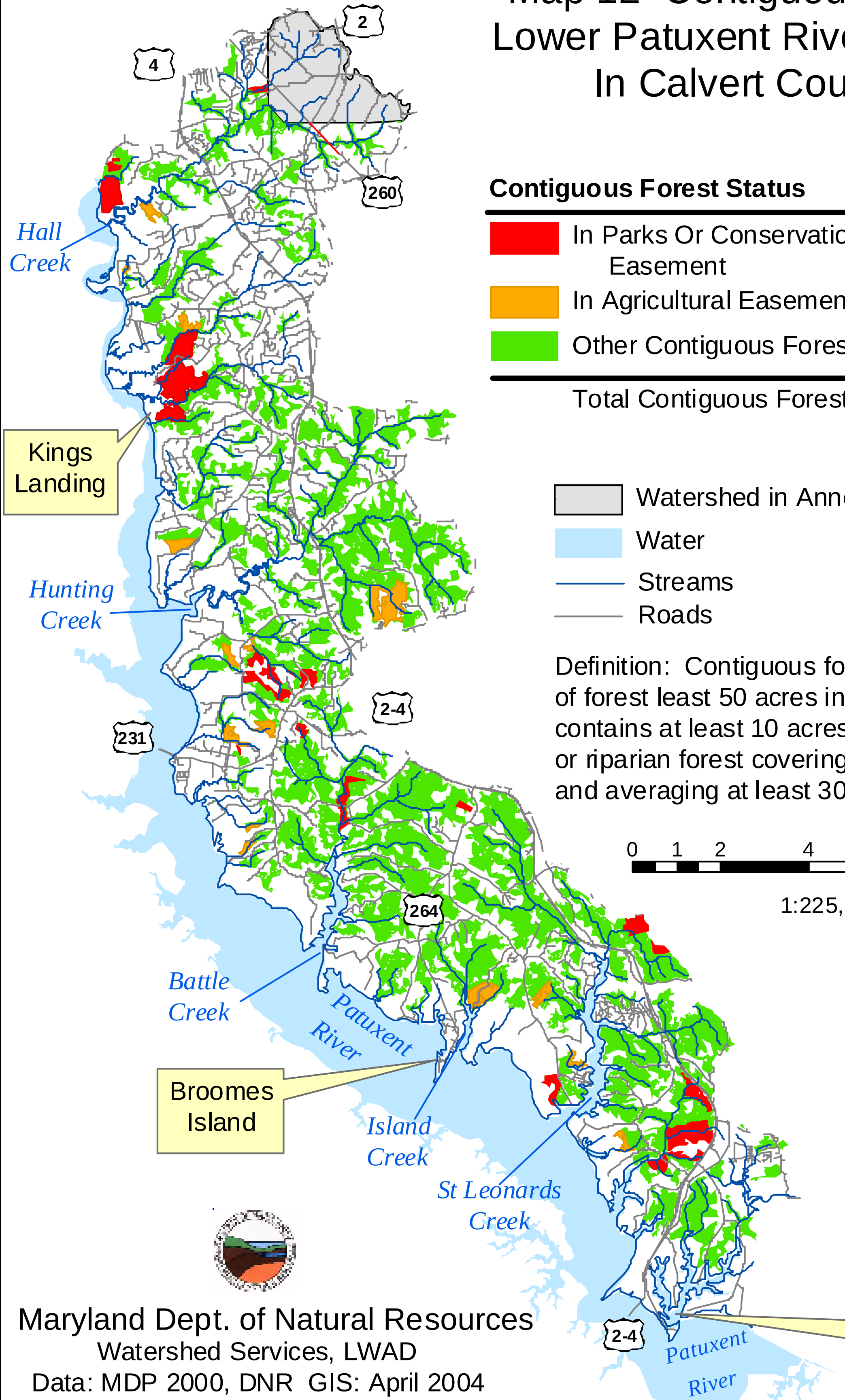
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP, DNR GIS: December 2003

Map 12 Contiguous Forest
Lower Patuxent River WRAS
In Calvert County

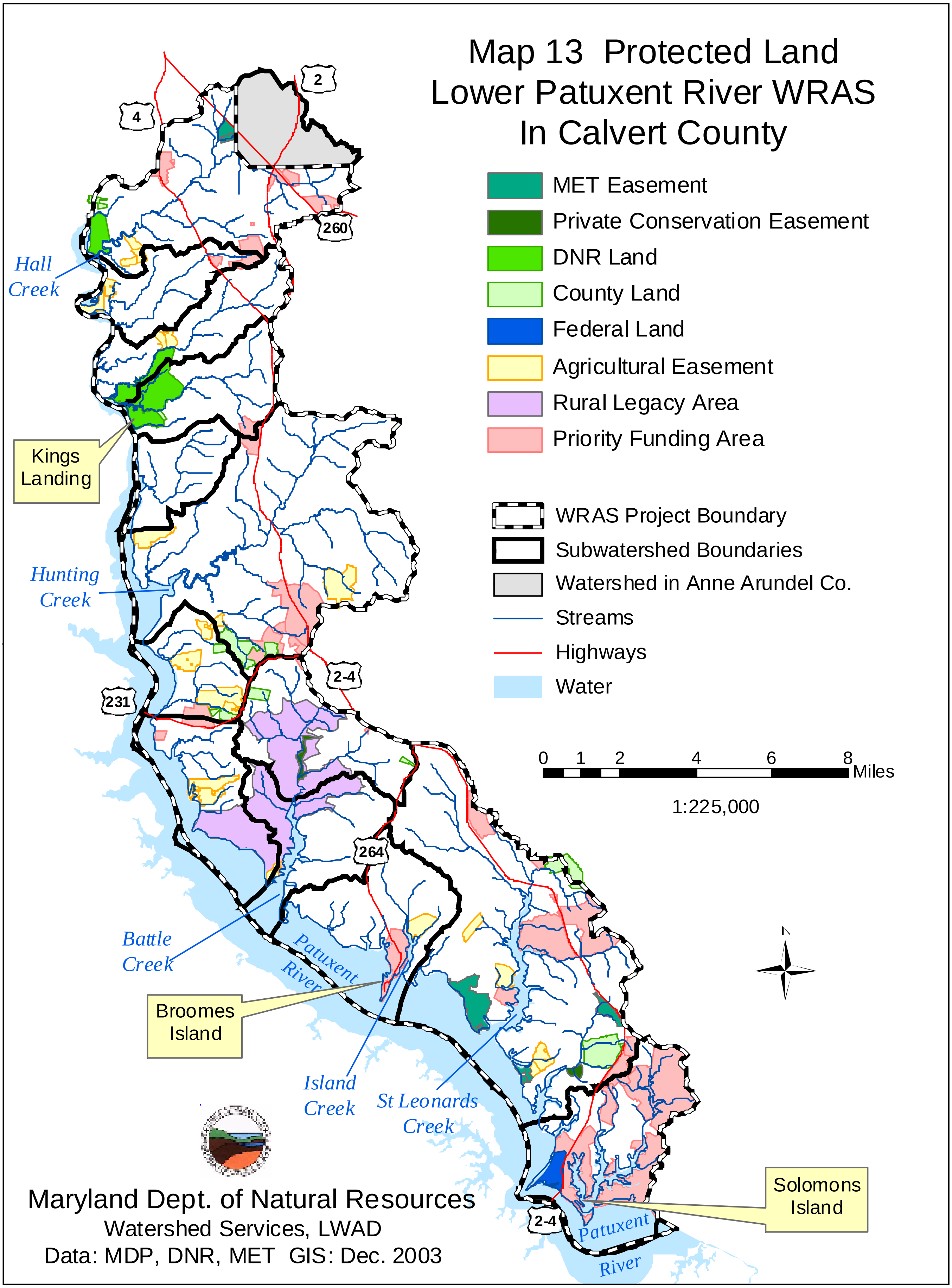
Contiguous Forest Status	Acres	Percent
In Parks Or Conservation Easement	2,036	6
In Agricultural Easement	1,089	3
Other Contiguous Forest	31,783	91
Total Contiguous Forest	34,908	100

Watershed in Anne Arundel Co.
Water
Streams
Roads

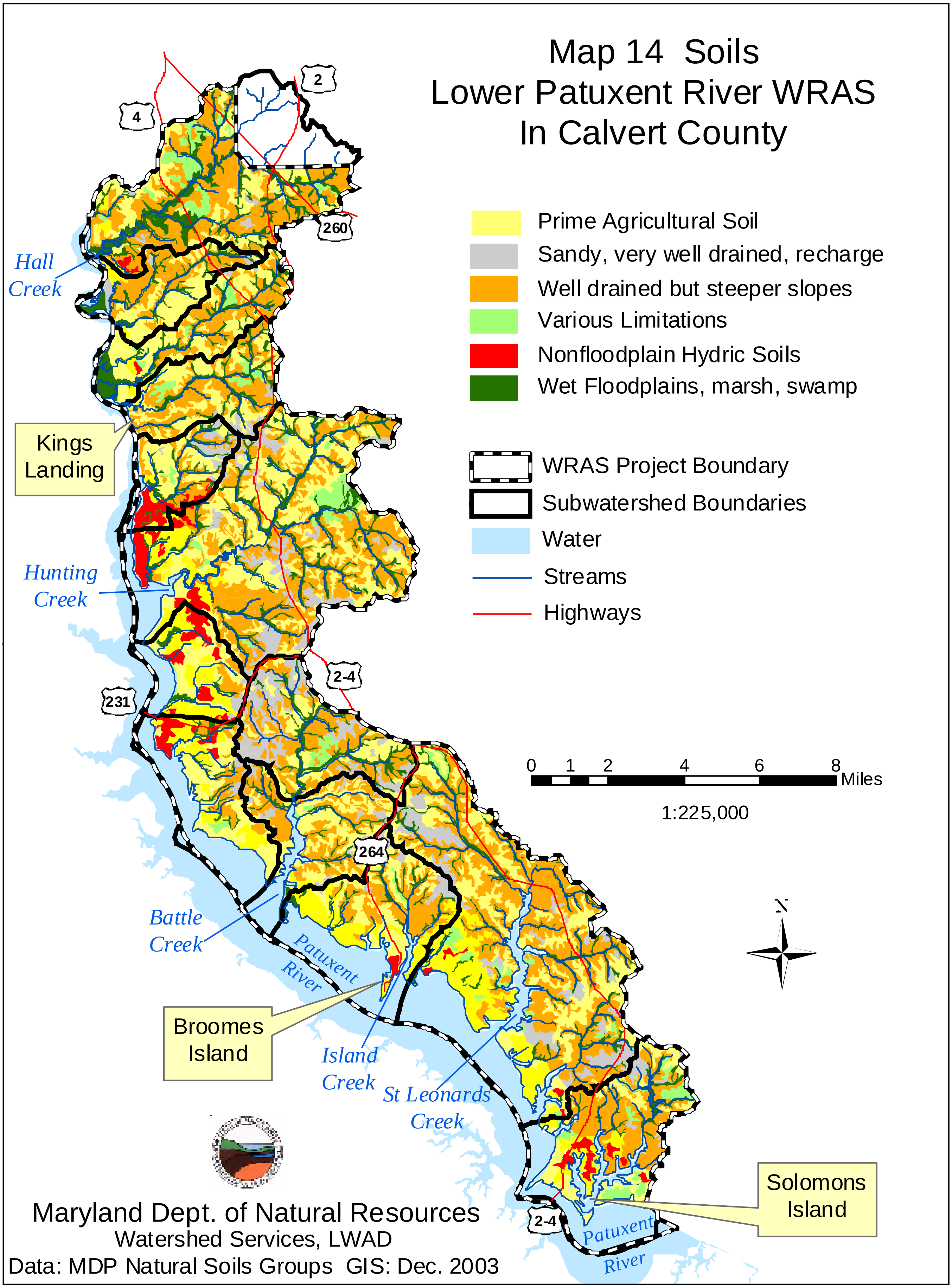
Definition: Contiguous forest is a block of forest least 50 acres in size that contains at least 10 acres of forest interior, or riparian forest covering at least 50 acres and averaging at least 300 feet wide.

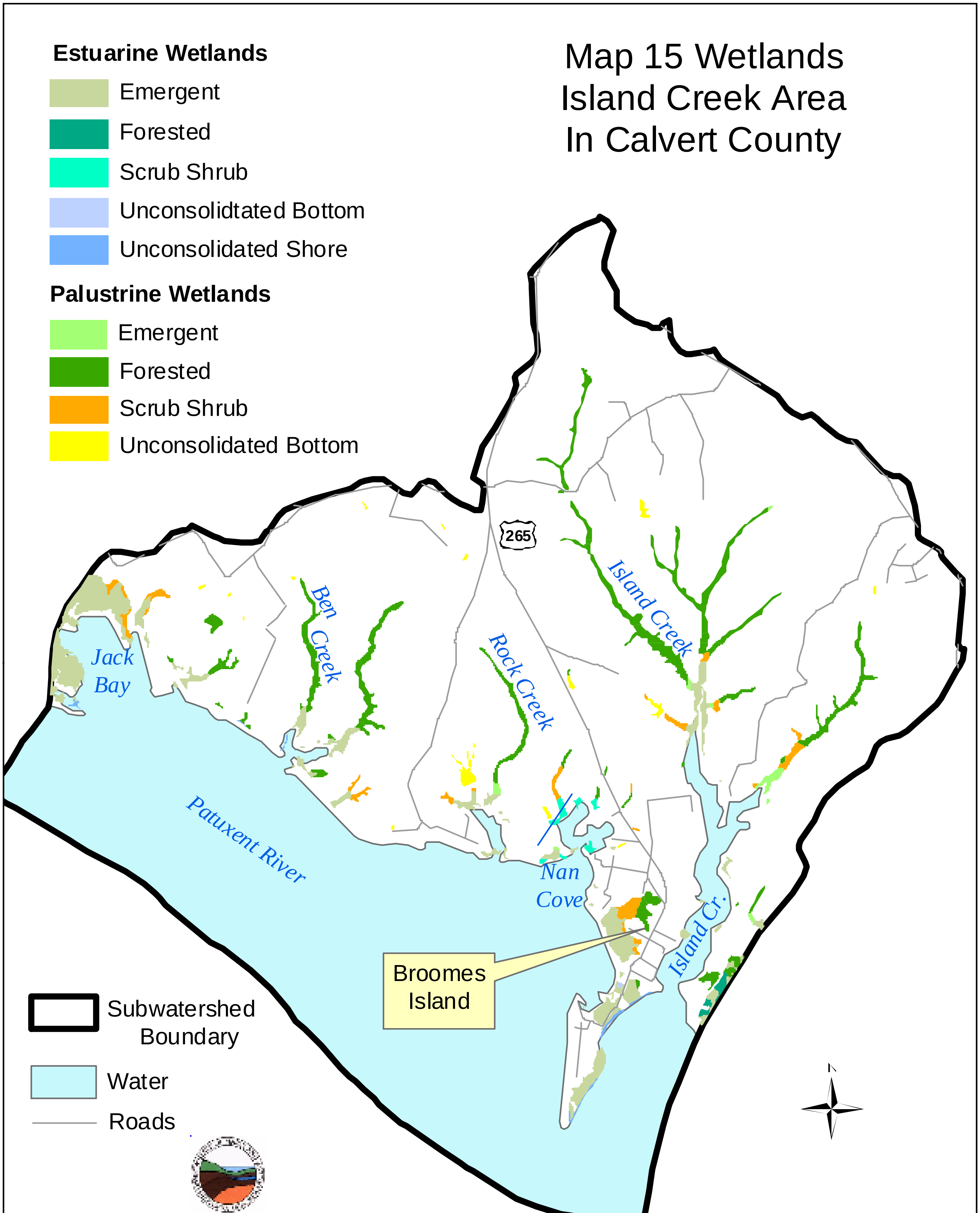


Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP 2000, DNR GIS: April 2004



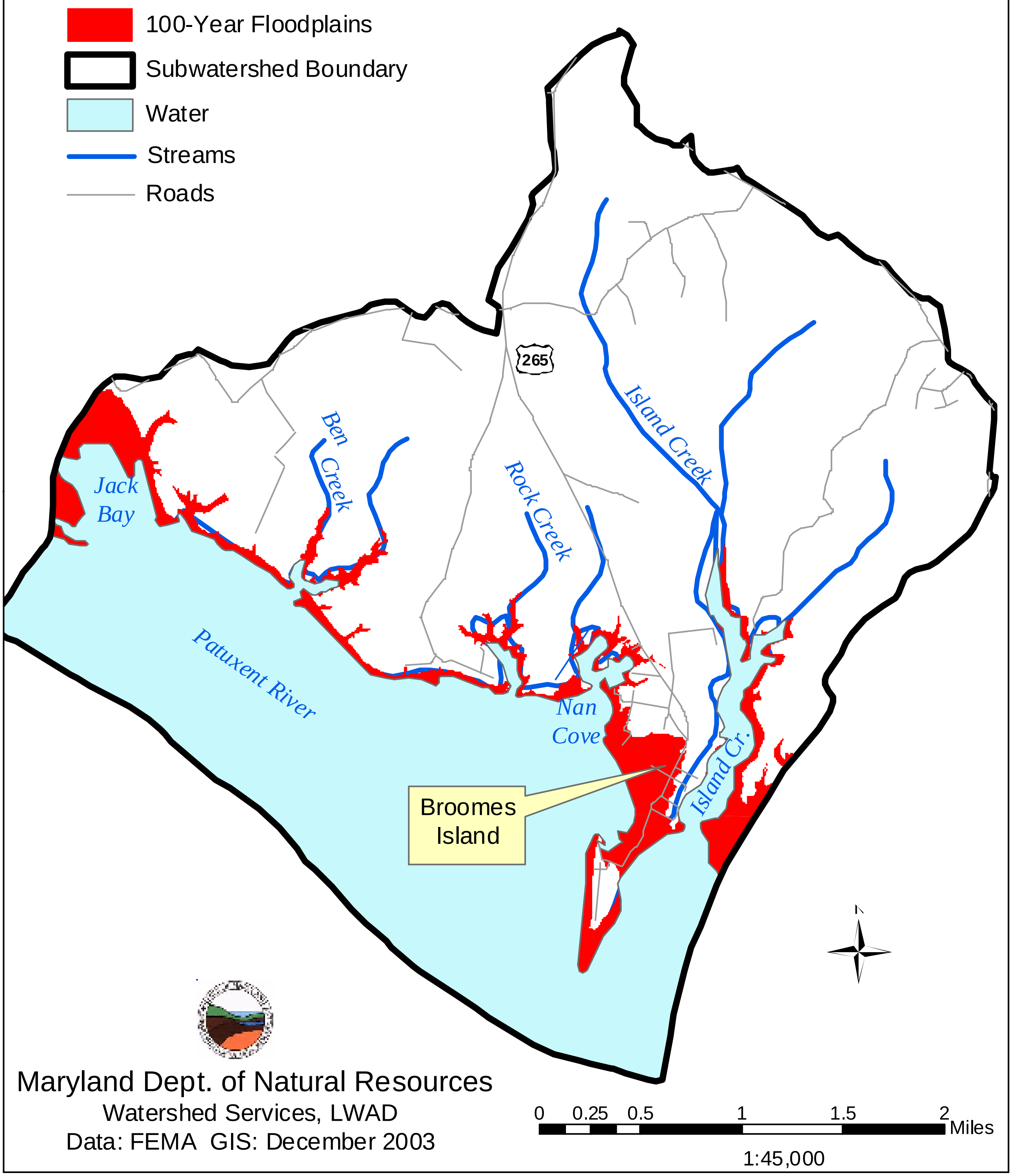
Map 13 Protected Land
Lower Patuxent River WRAS
In Calvert County
MET Easement
Private Conservation Easement
DNR Land
County Land
Federal Land
Agricultural Easement
Rural Legacy Area
Priority Funding Area
WRAS Project Boundary
Subwatershed Boundaries
Watershed in Anne Arundel Co.
Streams
Highways
Water
0 1 2 4 6 8 Miles
1:225,000
2
4
260
2-4
231
264
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP, DNR, MET GIS: Dec. 2003


Map 14 Soils
Lower Patuxent River WRAS
In Calvert County
Prime Agricultural Soil
Sandy, very well drained, recharge
Well drained but steeper slopes
Various Limitations
Nonfloodplain Hydric Soils
Wet Floodplains, marsh, swamp
WRAS Project Boundary
Subwatershed Boundaries
Water
Streams
Highways
0 1 2 4 6 8 Miles
1:225,000
2
4
260
2-4
231
264
2-4
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
Patuxent River
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP Natural Soils Groups GIS: Dec. 2003

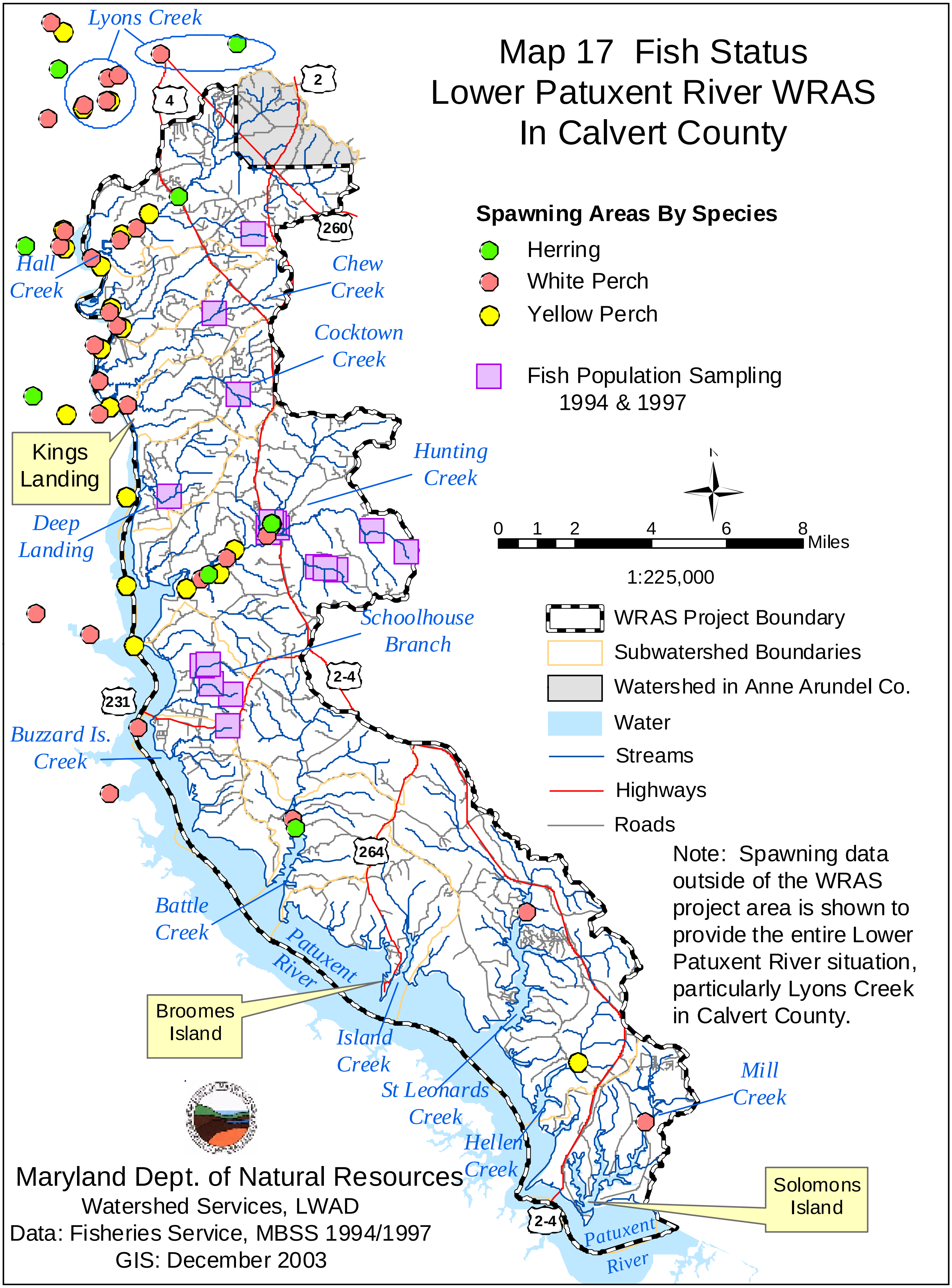


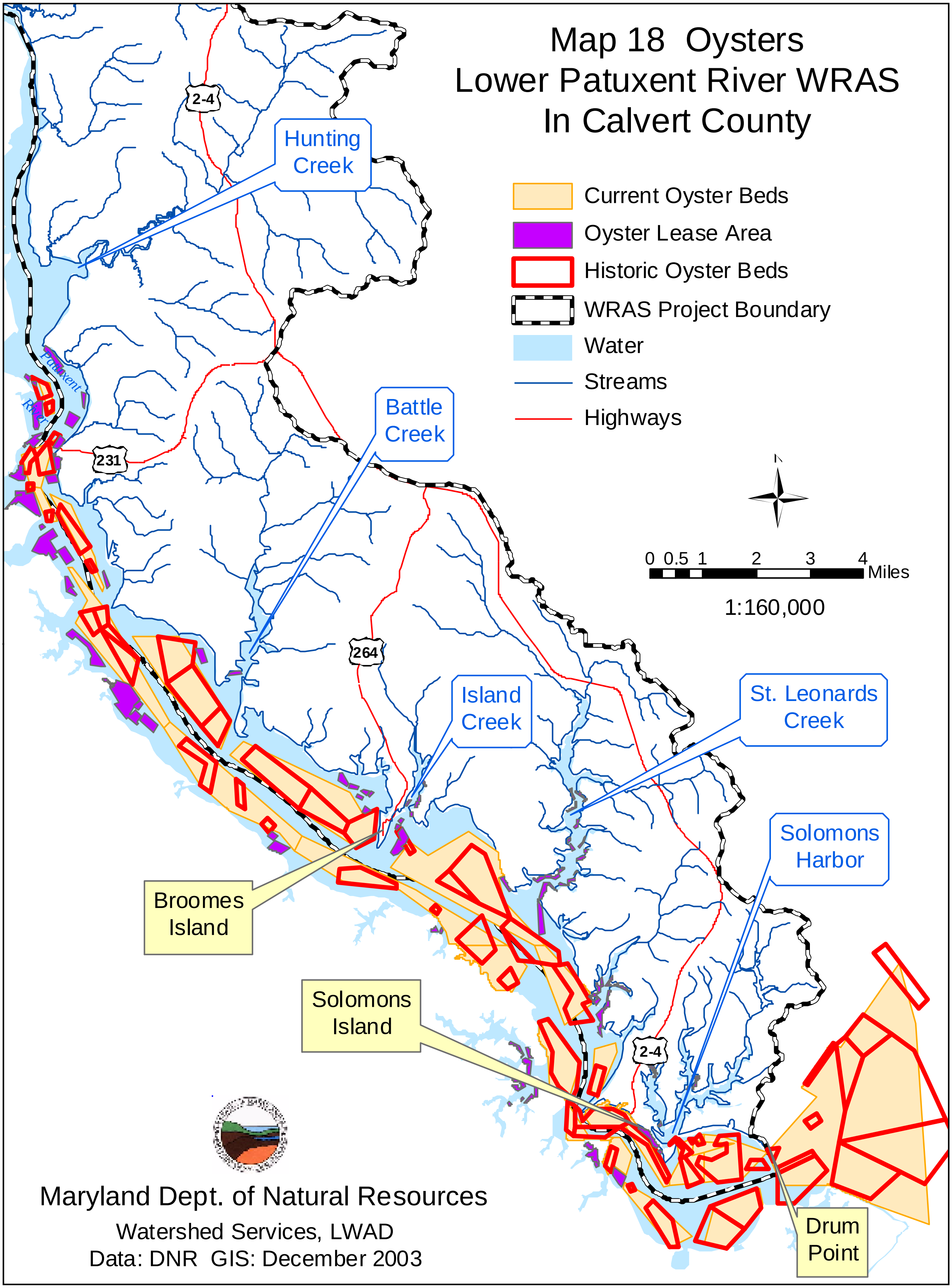
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: DNR GIS: December 2003

Map 16 Floodplains
Island Creek Area In Calvert County

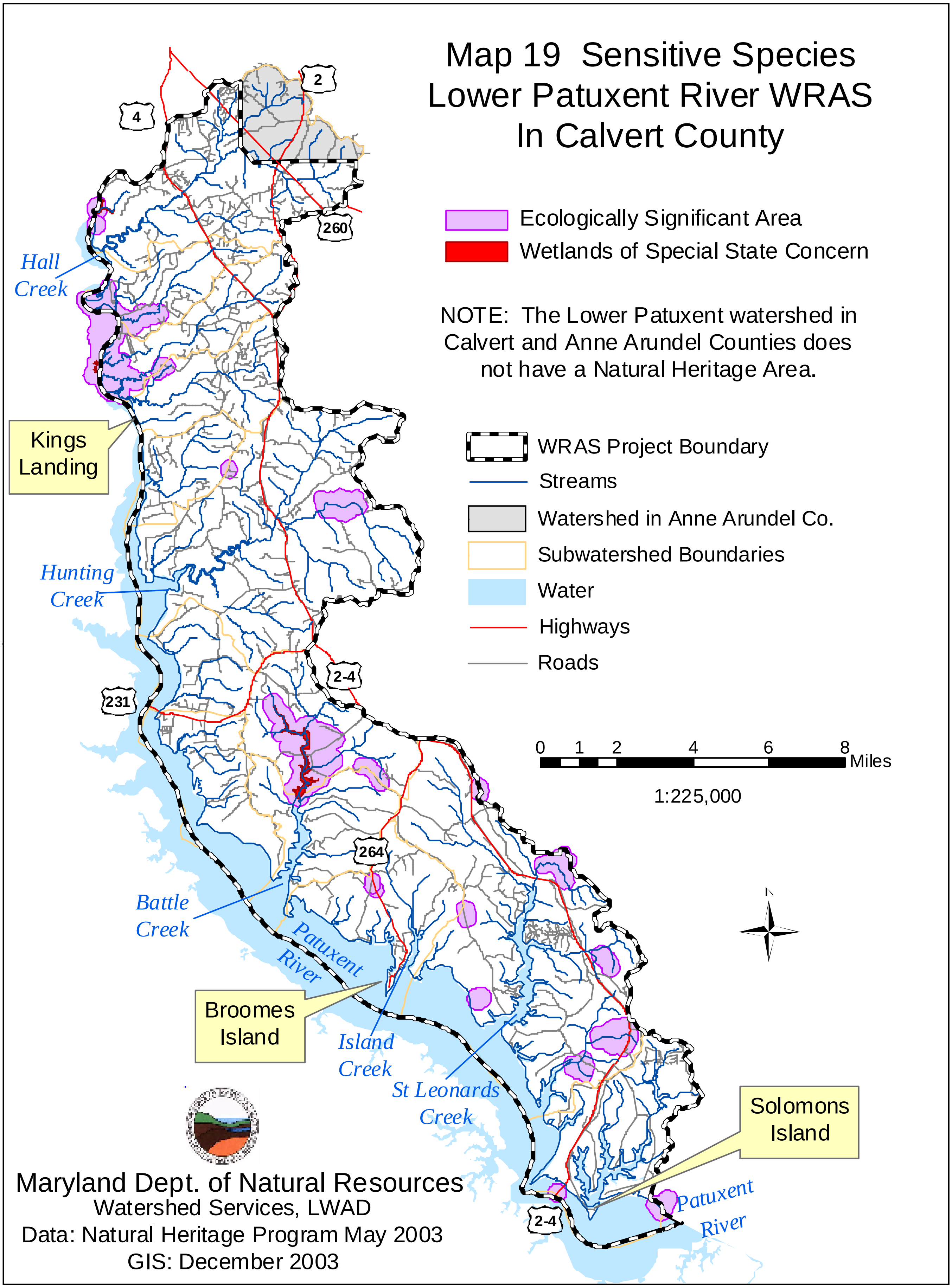


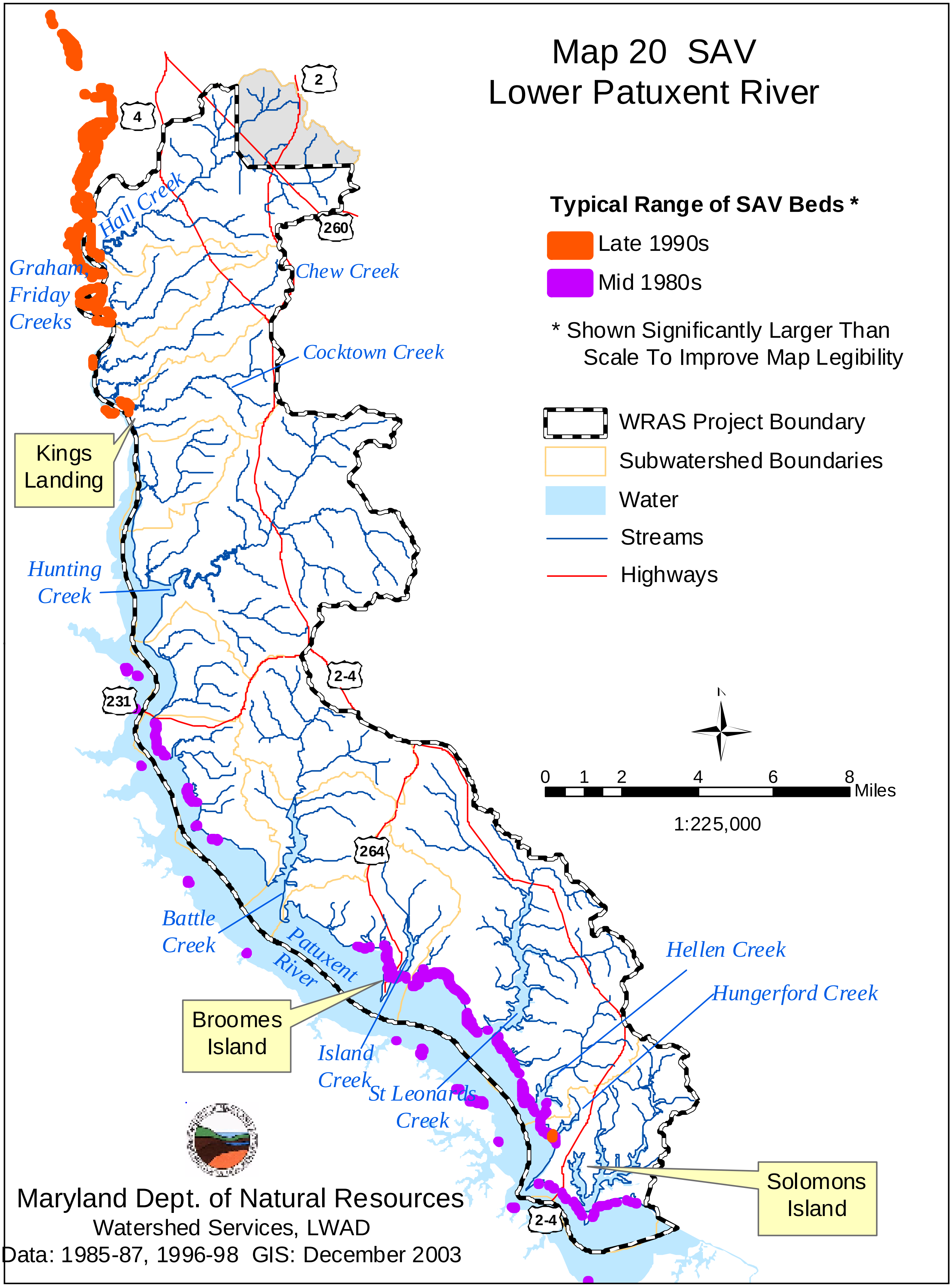
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: FEMA GIS: December 2003

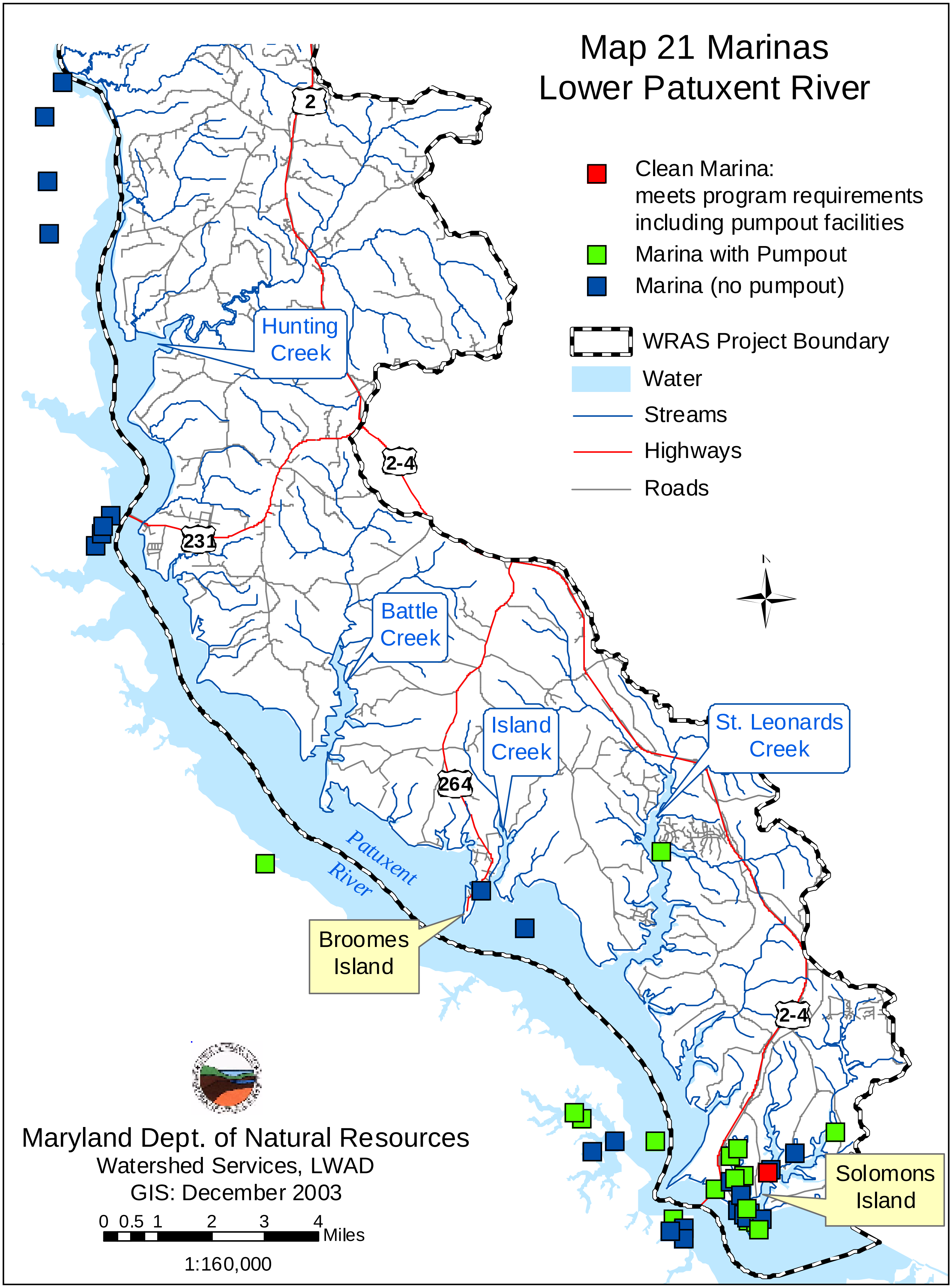

Map 17 Fish Status
Lower Patuxent River WRAS
In Calvert County
Spawning Areas By Species
Herring
White Perch
Yellow Perch
Fish Population Sampling
1994 & 1997
0 1 2 4 6 8 Miles
1:225,000
WRAS Project Boundary
Subwatershed Boundaries
Watershed in Anne Arundel Co.
Water
Streams
Highways
Roads
Note: Spawning data outside of the WRAS project area is shown to provide the entire Lower Patuxent River situation, particularly Lyons Creek in Calvert County.
Lyons Creek
Hall Creek
Chew Creek
Cocktown Creek
Kings Landing
Hunting Creek
Deep Landing
Schoolhouse Branch
Buzzard Is. Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Hellen Creek
Mill Creek
Solomons Island
4
2
260
2-4
231
264
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: Fisheries Service, MBSS 1994/1997
GIS: December 2003

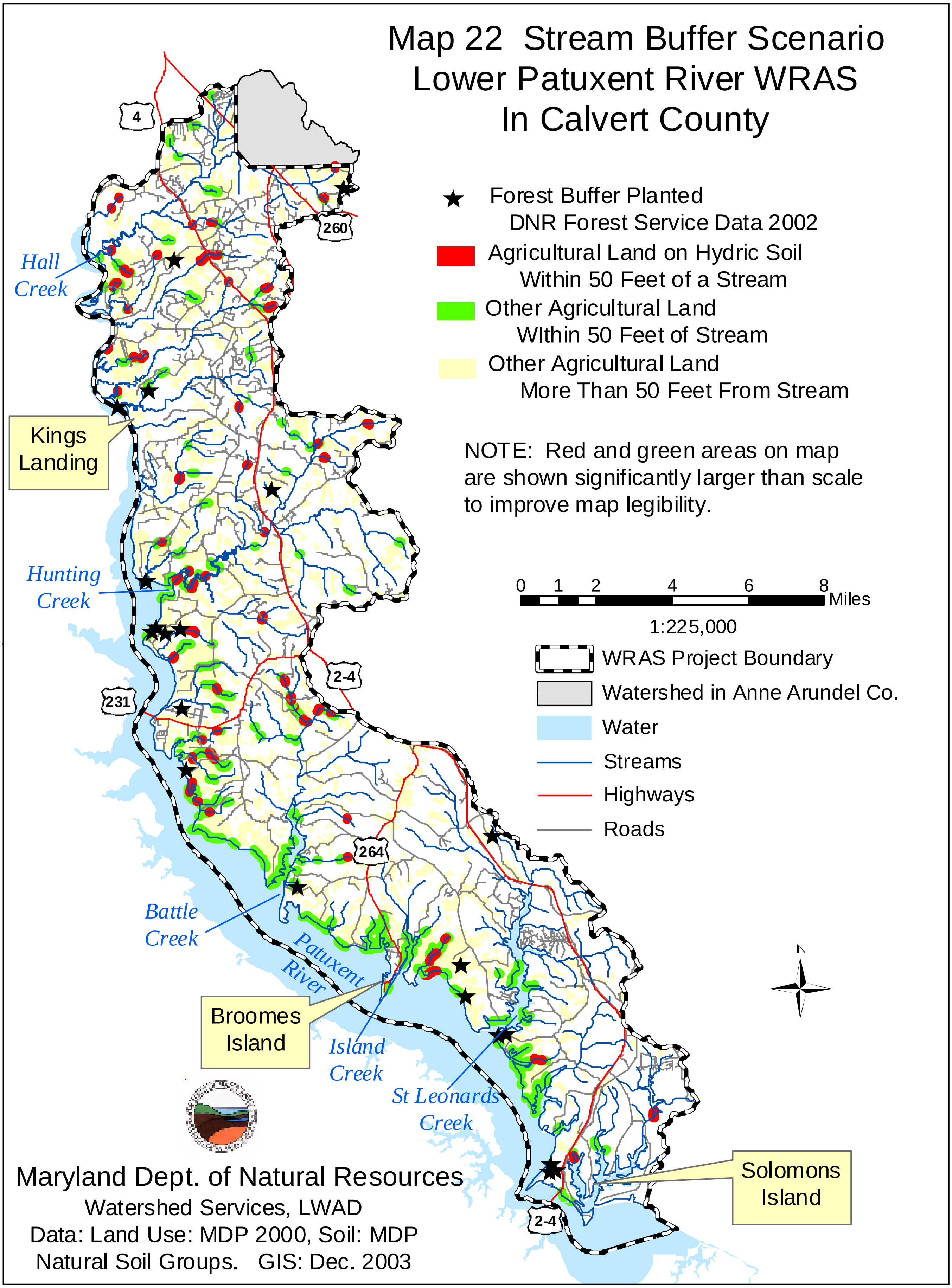


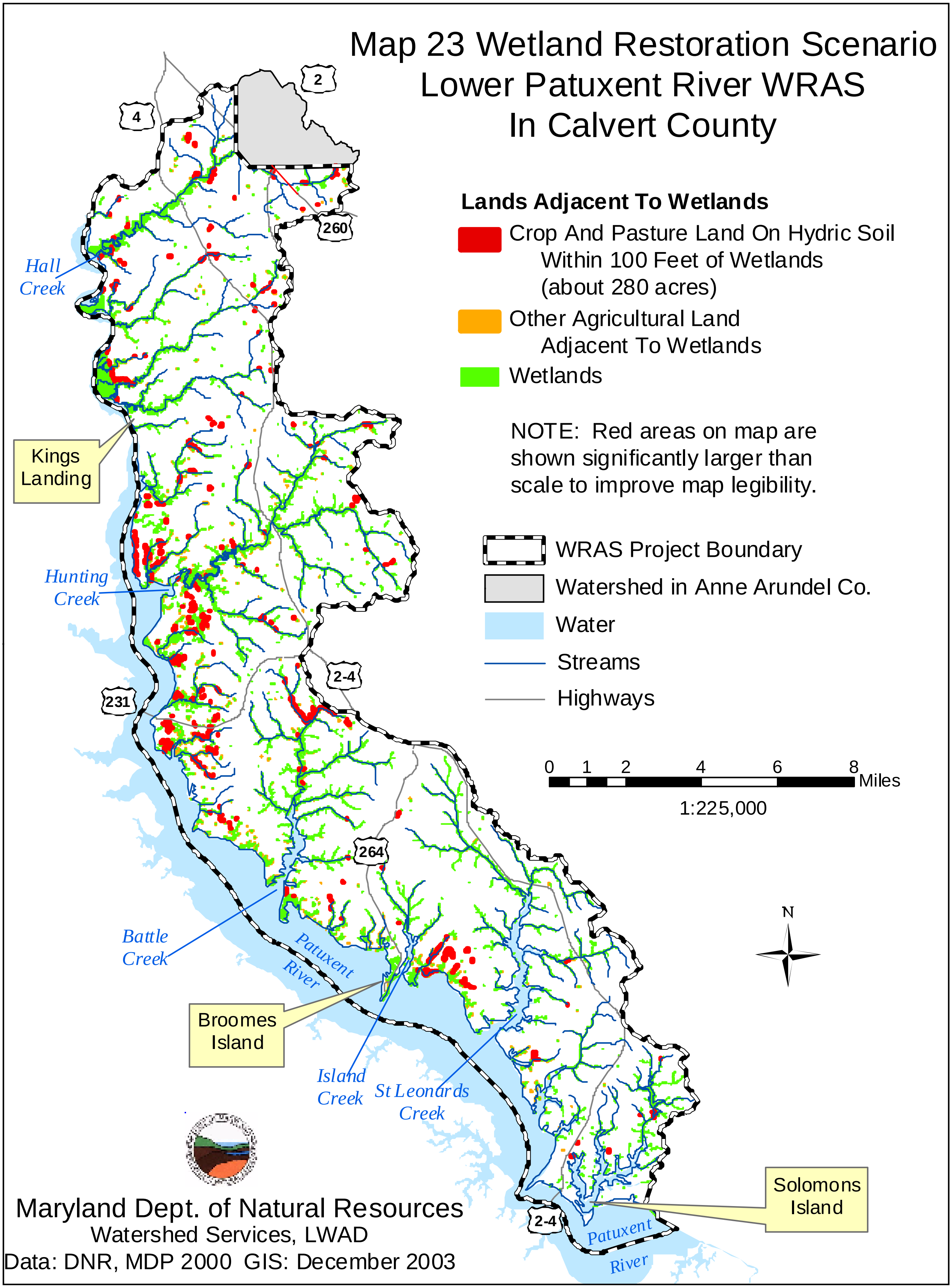
Map 18 Oysters
Lower Patuxent River WRAS
In Calvert County
Current Oyster Beds
Oyster Lease Area
Historic Oyster Beds
WRAS Project Boundary
Water
Streams
Highways
0 0.5 1 2 3 4 Miles
1:160,000
Hunting Creek
Battle Creek
Island Creek
St. Leonards Creek
Solomons Harbor
Broomes Island
Solomons Island
Drum Point
Patuxent River
2-4
231
264
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: DNR GIS: December 2003


Map 19 Sensitive Species
Lower Patuxent River WRAS
In Calvert County
Ecologically Significant Area
Wetlands of Special State Concern
NOTE: The Lower Patuxent watershed in Calvert and Anne Arundel Counties does not have a Natural Heritage Area.
WRAS Project Boundary
Streams
Watershed in Anne Arundel Co.
Subwatershed Boundaries
Water
Highways
Roads
0 1 2 4 6 8 Miles
1:225,000
2
4
260
2-4
231
264
2-4
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
Patuxent River
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: Natural Heritage Program May 2003
GIS: December 2003


Map 20 SAV
Lower Patuxent River
Typical Range of SAV Beds *
Late 1990s
Mid 1980s
* Shown Significantly Larger Than Scale To Improve Map Legibility
WRAS Project Boundary
Subwatershed Boundaries
Water
Streams
Highways
0 1 2 4 6 8 Miles
1:225,000
Hall Creek
Graham, Friday Creeks
Chew Creek
Cocktown Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Hellen Creek
Hungerford Creek
Solomons Island
2
4
260
2-4
231
264
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: 1985-87, 1996-98 GIS: December 2003


Map 21 Marinas
Lower Patuxent River
Clean Marina: meets program requirements including pumpout facilities
Marina with Pumpout
Marina (no pumpout)
WRAS Project Boundary
Water
Streams
Highways
Roads
Hunting Creek
Battle Creek
Island Creek
St. Leonards Creek
Broomes Island
Solomons Island
Patuxent River
2
2-4
231
264
Maryland Dept. of Natural Resources
Watershed Services, LWAD
GIS: December 2003
0 0.5 1 2 3 4 Miles
1:160,000


Map 22 Stream Buffer Scenario
Lower Patuxent River WRAS
In Calvert County
Forest Buffer Planted
DNR Forest Service Data 2002
Agricultural Land on Hydric Soil
Within 50 Feet of a Stream
Other Agricultural Land
WIthin 50 Feet of Stream
Other Agricultural Land
More Than 50 Feet From Stream
NOTE: Red and green areas on map
are shown significantly larger than scale
to improve map legibility.
0 1 2 4 6 8 Miles
1:225,000
WRAS Project Boundary
Watershed in Anne Arundel Co.
Water
Streams
Highways
Roads
4
260
Hall Creek
Kings Landing
Hunting Creek
2-4
231
264
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
2-4
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: Land Use: MDP 2000, Soil: MDP
Natural Soil Groups. GIS: Dec. 2003


Map 23 Wetland Restoration Scenario
Lower Patuxent River WRAS
In Calvert County
Lands Adjacent To Wetlands
Crop And Pasture Land On Hydric Soil Within 100 Feet of Wetlands (about 280 acres)
Other Agricultural Land Adjacent To Wetlands
Wetlands
NOTE: Red areas on map are shown significantly larger than scale to improve map legibility.
WRAS Project Boundary
Watershed in Anne Arundel Co.
Water
Streams
Highways
0 1 2 4 6 8 Miles
1:225,000
N
4
2
260
2-4
231
264
2-4
Hall Creek
Kings Landing
Hunting Creek
Battle Creek
Patuxent River
Broomes Island
Island Creek
St Leonards Creek
Solomons Island
Patuxent River
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: DNR, MDP 2000 GIS: December 2003

APPENDIX A Findings from MBSS Fish Surveys

Key for Lable In Table Listed from North to South	**Stream / Description of Survey Area**
Fowlers Mill	Fowlers Mill Branch, tributary to Hall Creek
Chew Creek	Chew Creek mainstem
Cocktown Cr	Cocktown Creek mainstem
Deep Landing	Patuxent River unnamed tributary
Hunting Creek	Hunting Creek mainstem and unnamed tributaries
Schoolhouse Br	Schoolhouse Branch mainstem and unnamed tributary
Buzzard Is. Cr.	Buzzard Island Creek mainstem

Key For Color/Font Code* for fish species in the table below (white: no data)	**Tolerant** Fish that tend to survive greater pollution and poorer habitat conditions	*Moderate Tolerance Fish with mid-range ability to co-exist with pollution and varied habitat conditions*	**Intolerant** Fish that require good water quality and good habitat conditions

MBSS Findings on Fish Species Lower Patuxent In Calvert County "**P**" means species is present	Fowlers_Mill_	Chew Creek	Cocktown Cr	Deep Landing	Hunting_Creek_	Schoolhouse_Br.	Buzzard Is. Cr.
American Eel		**P**		**P**	**P**	**P**	
Banded Killfish					**P**		
Blacknose Dace	**P**	**P**	**P**	**P**		**P**	**P**
Bluegill		**P**	**P**	**P**	**P**	**P**	
Bluespotted Sunfish					**P**		
Brown Bullhead					**P**		

MBSS Findings on Fish Species Lower Patuxent In Calvert County "**P**" means species is present	Fowlers_Mill_	Chew Creek	Cocktown Cr	Deep Landing	Hunting_Creek_	Schoolhouse_Br.	Buzzard Is. Cr.
Chain Pickerel					**P**		
Creek Chubsucker		**P**		**P**	**P**		
Eastern Mudminnow		**P**	**P**	**P**	**P**	**P**	
Eastern Silvery Minnow						**P**	
Fathead Minnow		**P**					
Golden Shiner					**P**		
Lamprey Sp.						**P**	
Largemouth Bass				**P**	**P**		
Mosquitofish				**P**	**P**		
Pumpkinseed				**P**	**P**	**P**	
Redfin Pickerel		**P**		**P**	**P**	**P**	
Spottail Shiner					**P**		
Striped Bass					**P**		
Tadpole Madtom					**P**		
Tessellated Darter	**P**	**P**	**P**	**P**	**P**	**P**	
White Catfish					**P**		
White Sucker					**P**		
Yellow Perch					**P**		

* Rating of nontidal fish by tolerance level is adapted from the following document: *Maryland Biological Stream Survey, Ecological Status of Nontidal Streams in Six Basins Sampled in 1995.* Maryland Dept. of Natural Resources, Chesapeake Bay and Watershed Programs, Monitoring and Nontidal Assessment. CBWP-MANTA-EA-97-2. May 1997.