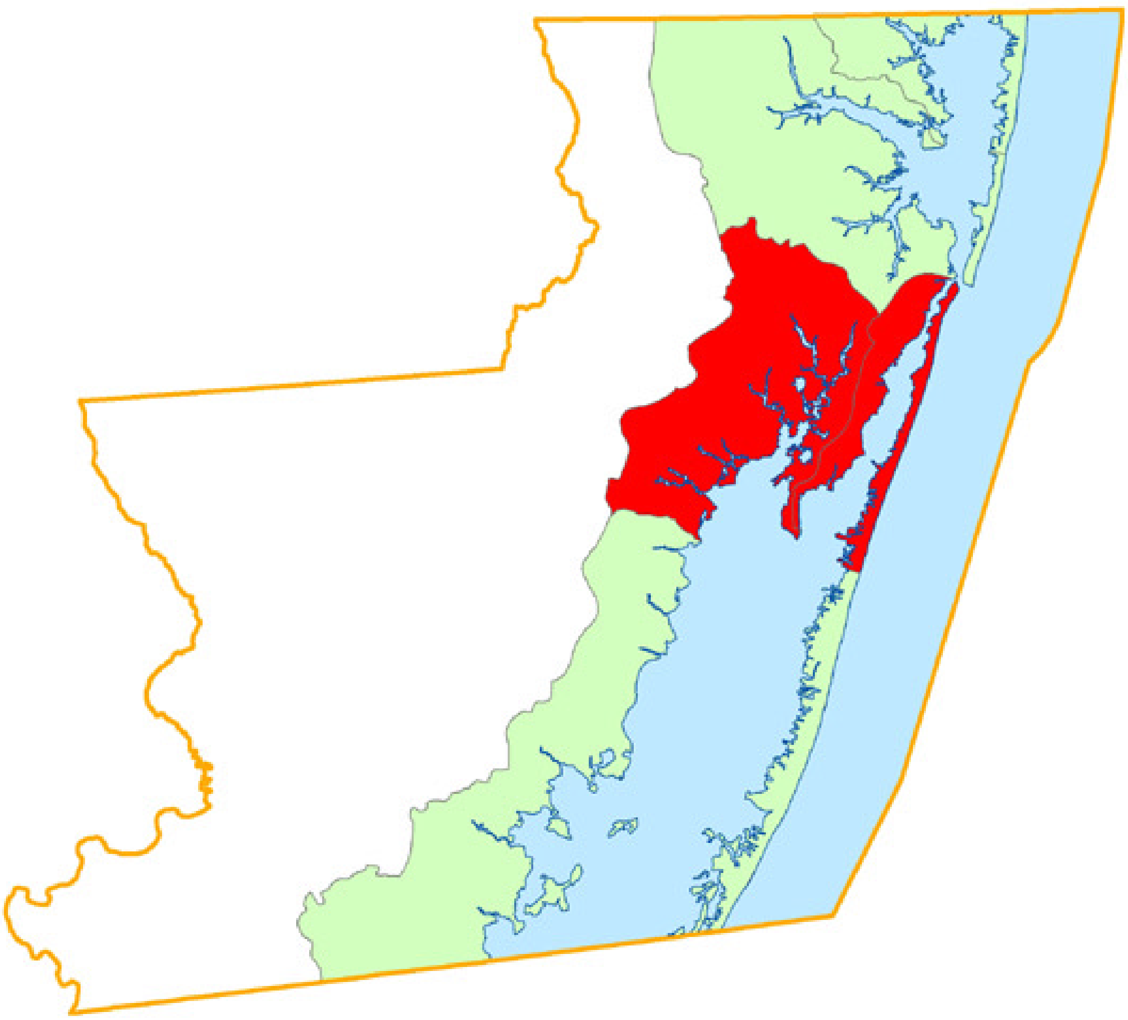
Newport Bay and Sinepuxent Bay Watersheds Characterization

December 2003

In support of Worcester County's
Watershed Restoration Action Strategy
for the Newport Bay and Sinepuxent Bay Watersheds



Product of the Maryland Department of Natural Resources Watershed Services
In partnership with Worcester County

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EXECUTIVE SUMMARY
For the Newport Bay and Sinepuxent Bay Watersheds Characterization

Worcester County, Maryland is receiving Federal grant funding to prepare a Watershed Restoration Action Strategy (WRAS) for the Newport Bay and Sinepuxent Bay Watersheds. These watersheds are in the central portion of the Maryland Coastal Bays drainage area. The WRAS project area encompasses about 46,204 acres including about 11,471 acres of open water.

The purpose of the WRAS project is for Worcester County and various stakeholders to determine local priorities for protection and restoration of water quality and habitat.

As part of the 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 inspection data to catalog issues and rate problem severity) and a synoptic survey (analyzes benthic macroinvertebrates, fish and water samples with focus on nutrients). The County will use this information to help generate the Watershed Restoration Action Strategy.

Water Quality

Maryland's Coastal Bays, including Newport and Sinepuxent Bays, are salty water bodies with salinty that varies between 27 parts per thousand (ppt) to 34 ppt.

Tidal portions of Newport Bay and Sinepuxent Bay are listed by the Maryland Department of the Environment (MDE) for water quality impairments associated with low dissolved oxygen, nutrients and fecal coliform bacteria. Both watersheds are affected by MDE's statewide fish consumption advisory intended to protect people from consuming too much methylmercury.

The Newport Bay watershed has an approved Total Maximum Daily Load (TMDL) that limits nitrogen entering three tidal creeks and the bay. It also limits biological oxygen demand entering Kitts Branch. Nutrient loads in this watershed are mostly from nonpoint sources. Nonpoint sources generate about 49% of the nitrogen load, point sources contribute about 30% and the remainder comes from atmospheric deposition and groundwater. Phosphorus loads are about 80% from nonpoint sources and 20% from point sources. Nonpoint source phosphorus in the water is mostly associated with movement of sediment.

Sinepuxent Bay has a small area closed to shellfish harvesting due to a sewage effluent discharge from the Assateague Island Park visitor facility.

The average stream base flow nitrate concentration for nontidal streams flowing into Maryland's Coastal Bays south of Berlin was measured at 1.75 milligrams per liter (mg/l) during the winters of 1999 and 2000. This level is significantly higher than the previously assumed level of 0.72 mg/l.

Average groundwater nitrate was found to be low in most areas. However, high nitrates in groundwater, ranging from 5.01 mg/l to 8.00 mg/l, characterized the area bounded by the tidal portion of Ayer Creek on the west, Newport Creek on the south and Sinepuxent Bay on the east. Several smaller areas exhibited higher average nitrate levels.

The Landscape

According to Maryland Department of Planning 2000 data, land use differs in the two watersheds. The Newport Bay watershed is relatively rural: 11% developed, 34% agriculture, 43% forest/scrub and 12% wetland. The Sinpuxent Bay watershed is 22% developed, 11% agriculture, 31% forest, 24% wetland and 12% other land types like beach.

Average impervious area in both watersheds is lower overall. The greatest concentration of impervious area is in the Town of Berlin, which drains to Newport Bay.

Both watersheds have significant green infrastructure, forest with large interior area and wetlands. In the Newport Bay watershed, most of this land is not protected from land use conversion. A large proportion of these areas in Sinepuxent Bay watershed are protected by the Assateague Island parks system.

About 37% of these watersheds is prime agricultural land. Over 48% of the soils in these watersheds exhibit hydric conditions. Some areas of hydric soils are ditched to improve drainage.

The most prevalent wetland type in both watersheds is emergent wetland. However, the Newport Bay watershed has a large portion of forested palustrine wetlands (freshwater wetlands not associated with lakes, rivers or streams). Sinepuxent Bay watershed has a relatively large portion of unconsolidated shore wetlands – mostly on the bay-side of the barrier island.

In the long term, a large area of the WRAS Project Area may be affected by sea level rise.

Living Resources and Habitat

Tidal fish species of commercial and recreational importance are showing signs of improvement following significant declines in population in the 1980s and 1990s.

Sensitive species identified in these watersheds include 20 plant and five animal species including two Federally listed birds: the bald eagle and the piping plover.

Submerged Aquatic Vegetation (SAV) beds have increased in area since monitoring began in the 1980s. SAV in Maryland's Coastal Bays was nearly eliminated by disease in the 1930s. Sinepuxent Bay has a significantly larger area of SAV than Newport Bay.

Restoration Targeting Tools

Scenarios for potential stream buffer restoration and wetland restoration targeting suggests that opportunities for further assessment may be available. Current field data gathered by the Stream Corridor Assessment and the Synoptic Survey will help develop a list of issues for further investigation and identify sites that could be used in restoration efforts.

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INTRODUCTION

Background

In 1998, Maryland completed an assessment of all 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 Newport Bay and Sinepuxent Bay Watersheds in Worcester County, where the County, DNR and other local cooperators, both public and private, are engaged in developing a watershed management strategy.

Location

The Newport Bay and Sinepuxent Bay watersheds are located within the Maryland Coastal Bays drainage area as shown in Map 1 Location. These watersheds are located entirely within Worcester County as highlighted in Map 2 Project Area. This area is the focus of the WRAS and this Watershed Characterization. The adjacent table shows that about one quarter of the WRAS project area is open water. Map 2 also shows that DNR subdivides the Newport Bay watershed into four "12-digit" subwatersheds for analytical purposes. No Sinepuxent Bay subwatersheds are defined by DNR. The table Subwatersheds provides additional details on these subwatersheds.

Watershed Acreage Summary
MDP 2000 Land Use/Land Cover

Watershed	Land	Water	Total
Newport Bay	27,229	5,264	32,493
Sinepuxent Bay	7,504	6,207	13,711
Newport and Sinepuxent Bays	34,733	11,471	46,204

Purpose of the Characterization

One of the earliest steps in devising a WRAS is to characterize the watershed using available information. This Watershed Characterization is intended to meet several objectives:

– briefly summarize the most important information and issues

– provide preliminary findings
– identify information or analysis needs
– suggest opportunities for additional characterization and restoration work.
– provide a common base of knowledge about the Newport Bay and Sinepuxent Bay Watersheds 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 involving an array of additional inputs:

– self-investigation by Worcester 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. This is also part of the technical assistance offered by DNR. Findings of the 2002 synoptic survey of the streams in the Newport Bay and Sinepuxent Bay watersheds are reported in Appendix D.

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 (including the 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.

WATER QUALITY

Water quality is in many respects the driving condition in the health of Maryland's streams. Historically, the emphasis has been 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.

Subwatersheds
Newport Bay and Sinepuxent Bay WRAS Project Area

"8-Digit" Watershed Number/ Name	"12-Digit" Subwatershed Name and Number		Area in Acres			Description
			Water	Land*	Total	
02130104 **Sinepuxent Bay**	same as 8-digit	0681	6,207	7,504	13,711	Entire 8-digit Watershed
02130105 **Newport Bay**	Marshall Creek	0682	2,310	5,597	7,907	Includes Massey Br.
	Newport and Porter Creeks	0683	2,368	10,632	13,000	Includes Catbird and Barrett Creeks
	Ayer and Trappe Creeks	0684	541	6,877	7,418	
	Trappe Creek Headwaters	0685	45	4,123	4,168	Includes the Town of Berlin
02130105	**Newport Bay Watershed**		5,264	27,229	32,493	Entire 8-digit Watershed

* In this table, the land column includes wetland acres.

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 Newport Bay and Sinepuxent Bay watersheds are 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 portions of the territorial seas and estuarine portions of bays and tributaries except: Ocean City Harbor above the entrance to West Ocean City Harbor

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 cannot be used to the full extent envisioned by their designated use in Maryland regulation due to water quality or habitat impairments. Tracking of 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 the Newport Bay and Sinepuxent Bay watersheds include several types of water quality or habitat problems:

- Dissolved Oxygen
- Fecal Coliform Bacteria and Shellfish Harvesting Restrictions
- Nutrients (nitrogen and phosphorus)
- Fish Consumption Advisory

1. Dissolved Oxygen

The draft 2002 303(d) list identifies dissolved oxygen impairment in tidal portions of both Newport Bay and Sinepuxent Bay. The origins of the dissolved oxygen problem are listed: as natural and nonpoint sources related to human activity.

Aquatic life requires a range of dissolved oxygen (DO) concentrations in water to allow for respiration and survival. If DO concentrations diminish beyond the range of tolerance for the species in a water body, mobile species like fish attempt to leave low DO areas in search more suitable areas. Individuals unable to escape die when DO concentrations drop below tolerance levels.

To help ensure that waters of the State provide sufficient levels of dissolved oxygen to support aquatic life, the State of Maryland has a DO water quality standard in regulation. The standard requires that dissolved oxygen concentrations be maintained at 5.0 mg/l or higher. Water bodies in which DO levels are known to fall below 5.0 mg/l on a reoccurring basis are listed as impaired in the 303(d) list.

2. Fecal Coliform Bacteria and Shellfish Harvesting Restrictions

The tidal portions of Newport Bay and Sinepuxent Bay are listed for impairment by fecal coliform bacteria in the draft 2002 303(d) list. The origins of these bacteria were listed: as natural and nonpoint sources.

As shown in Map 3 Designated Uses and Use Restrictions, a small portion of Sinepuxent Bay is affected by shellfish harvesting restrictions. Tidal waters closest to the Assateague Island State Park Visitor Center are "restricted" which "means that no harvesting of oysters and clams is allowed at any time." These restrictions are applied by the Maryland Department of the Environment (MDE) to protect public health because areas near treated sewage effluent discharges have the potential to receive elevated levels fecal coliform bacteria.

Fecal coliform bacteria are a class of bacteria typically found in the digestive tract of warm-blooded animals, including humans. Fecal coliform bacteria 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 or human, waste. Depending on local conditions, sources of fecal contamination may include any of the following: inadequately treated sewage, failing septic systems, wild or domestic animals, urban stormwater carrying pet waste and similar sources.

3. Nutrients

The tidal portions of Newport Bay and Sinepuxent Bay are listed for impairment by nutrients in the 1996 303(d) list and in the draft 2002 303(d) list. The origins of these nutrients were listed: as natural and nonpoint sources related to human activity.

According to the November 2002 TMDL report for Newport Bay, nutrients are significant contributors to the use impairments in the Newport Bay system. High nutrient loads, particularly nitrogen in the Newport Bay, contribute to excessive algal blooms and concentrations of dissolved oxygen below the minimum State standard of 5.0 milligrams per liter (mg/l). The algae and dissolved oxygen problems impair local conditions and interfere with the designated uses of the Newport Bay system. The section Total Maximum Daily Loads gives additional information.

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 Coastal Bays, when high nutrient loads coincide with warm weather and sufficient light, 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. However, most of the nutrients in the Newport Bay and Sinepuxent Bays are generated within their respective watersheds. 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. The fraction of the total nitrogen load contributed by the atmosphere typically originates at burning fossil fuels in power plants and other industries, and from automobiles. Also see What Are the Effects of Nutrient Over-Enrichment?

4. Fish Consumption Advisory

Fish tissue sampling conducted in 2001 by MDE led to issuance of a fish consumption advisory in late 2001. An update to the advisory was issued by MDE in January 2003. The purpose of the advisory is to recommend limiting human consumption as described in the table below. The table is adapted from www.mde.state.md.us/CitizensInfoCenter/FishandShellfish

2003 Advisory On Fish Consumption Affecting Newport Bay and Sinepuxent Bay Recommended Maximum Allowable Meals Per Month					
Species	**Area Affected Statewide**	**General Population 8oz meal**	**Women 6oz meal**	**Children 3oz. meal**	**Contaminant**
Smallmouth & Largemouth Bass, Pickerel, Northern Pike, Walleye	Lakes and other impoundments	4	4	2	Methyl-mercury
	Rivers and streams	no advisory	8	8	
Bluegill	Lakes and other impoundments	8	8	8	

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

As of April 2004, one TMDL has been drafted that directly affects the WRAS project area encompassing the Newport Bay and Sinepuxent Bay watersheds. The report *Total Maximum Daily Loads of Nitrogen for Three Tidal Tributaries and Total Maximum Daily Load of Biological Oxygen Demand for One Tributary in the Newport Bay System, Worcester County, Maryland*, was approved by EPA in October 2003. The following sections summarize key parts of the TMDLs set in the report.

1. Nitrogen TMDLs In The Newport Bay Watershed

The Newport Bay mainstem receives flows and pollutants from numerous tributaries. In 1998, MDE conducted water quality monitoring to support its TMDL work. Analysis of this data and data from other sources covering the same time frame led MDE to the conclusion that control of nitrogen would limit algae growth in the Newport Bay system. In response, MDE has designed nitrogen TMDLs for several areas in the Newport Bay watershed as described below and summarized in the table Newport Bay Watershed Nitrogen TMDLs:

– There are five subwatersheds in the Newport Bay system that were addressed in the TMDL report. Three subwatersheds received nitrogen TMDLs (Ayer Creek, Newport Creek/Trappe Creek and Newport Bay), one BOD TMDL (Kitts Branch) and Marshall Creek had insufficient data and modeling limitations to allow generation of a TMDL.
– Nitrogen TMDLs are designed to address needs in specific areas of the Newport Bay system. The goals of these TMDLs are to improve water quality by maintaining dissolved oxygen concentrations above the State standard of 5.0 mg/l and by reducing algae blooms as measured by chlorophyll *a*. The nitrogen TMDL for Newport Bay is intended to constrain the total nitrogen load from the entire Newport Bay watershed while the TMDLs for its tributaries are intended to control local problem areas.
– The nitrogen TMDL for Newport Bay will require nearly a 47% total load reduction from current nitrogen loads. MDE reported that the total nitrogen load to Newport Bay is 407,551 pounds per year based on water quality monitoring. The sum of the monthly nitrogen loads listed as limits for Newport Bay in table below is 218,209 pounds per year of nitrogen.

Newport Bay Watershed Nitrogen TMDLs in Pounds/Month			
Watershed Area	**Summer June 1 to Oct. 31**	**Winter Nov. 1 to Mar. 31**	**Spring Apr. 1 to May 31**
Ayer Creek	215	2,085	1,824
Newport Cr. / Trappe Cr.	280	2,886	2,194
Newport Bay	4,491	32,270	17,202

2. Biological Oxygen Demand TMDL for Kitts Branch

Kitts Branch, which drains an area around the town of Berlin, flows into Trappe Creek and then to Newport Bay. The Biological Oxygen Demand (BOD) TMDL for Kitts Branch is designed to protect water quality by maintaining dissolved oxygen concentrations above the State standard of 5.0 mg/l during spring and summer low-flow conditions.

The spring TMDL is 6,132 pounds per month from April 1 to May 31. Based on 1998 monitoring data, the typical spring nitrogen load in Kitts Branch is about 100 pounds per day (around 3,000 pounds per month).

The summer TMDL is 1,369 pounds per month from June1 to Oct. 31. Based on 1998 monitoring data, the typical summer nitrogen load in Kitts Branch is about 28 pounds per day (around 840 pounds per month).

There are no BOD TMDL limits applied in winter from November 1 through March 31.

Water Quality Indicators–Setting Priority for Restoration and Protection

In Maryland's 1998 *Clean Water Action Plan*, the Newport Bay and Sinepuxent Bay watersheds were included in two categories for priority action: highest priority for restoration, and priority for protecting valued resources.

As the basis for the 1998 prioritization, a *Unified Watershed Assessment* was conducted to establish priorities for restoration and protection all for all watersheds (134) covering the State of Maryland. Part of this assessment employed indicators of water quality, landscape and living resources for each watershed where sufficient information was available. 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 in the following sections.

The Coastal Bays watersheds, the table summarizes the rankings for the water quality indicators used to allow comparison among them. The definition each category is listed below:

Water Quality Indicator Summary

Coastal Bay Watershed	Tidal Index	
	Habitat	Eutrophication
Assawoman	Category 1	Category 2
Isle of Wight	Category 1	Category 2
Sinepuxent	Category 2	Category 2
Newport	Category 1	Category 2
Chincoteague	Category 2	Category 2

Category 1 – watersheds in this category have the greatest problems compared to other watersheds. These watersheds are assigned the highest priority for restoration.

Category 2 – watersheds that do not have conditions to qualify for either Category 1 or Category 3. Both restoration and protection would be addressed in these watersheds as practicable.

Category 3 – watersheds with relatively very few problems and high quality conditions. These watershed are assigned the highest priority for protection.

Water Quality Monitoring

Various agencies conduct on-going water quality-related monitoring in the Newport Bay and Sinepuxent Bay area, including DNR, MDE, the National Park Service and volunteers working with Maryland's Coastal Bays Program. Map 4 Monitoring Water Quality shows some of these monitoring stations (mostly those used for the Newport Bay TMDL).

Maryland's Coastal Bays Program distributes information like current conditions via the Internet at http://www.dnr.maryland.gov/coastalbays/index.html . The Internet site offers other information like analysis of data from the four fixed monitoring stations and labeled on Map 4.

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

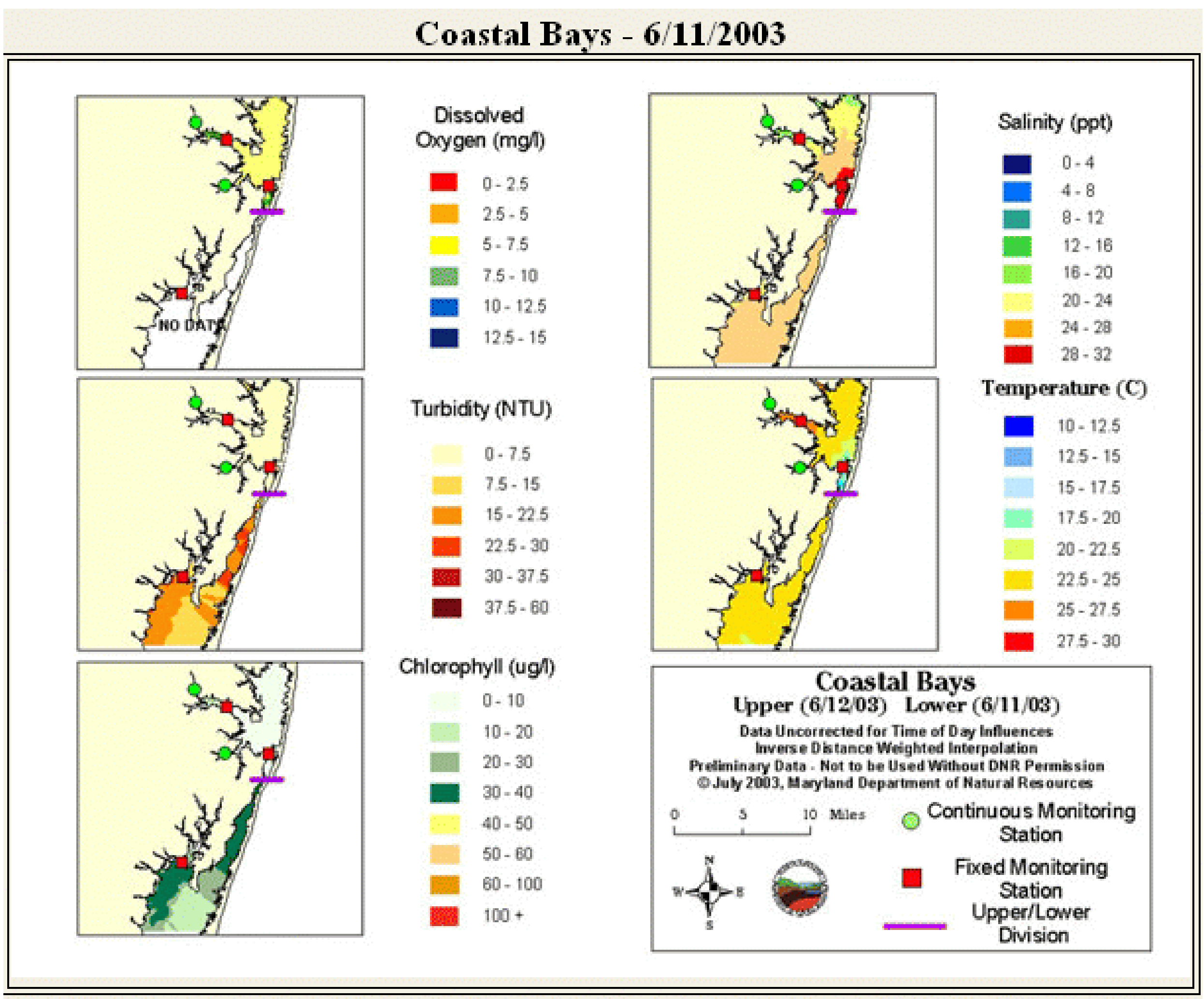
Monitoring Stations At Fixed Locations In The Newport Bay and Sinepuxent Bay Watersheds	
Ayer Creek at Rt. 376 - AYR0017	Newport Bay near Newport Neck - XCM4878
Trappe Creek at Saddle Creek - TRC0043	Marshall Creek east of Rick’s Point - MSL0011

Water Quality Analysis

1. Algae [7]

To estimate relative population levels of green and blue-green algae present in a water body, the concentration of Chlorophyll *a* in water is used as an indirect estimate of the aggregate population. Higher Chlorophyll *a* concentrations indicate higher algae populations.

Algae problems tend to occur more in Trappe, Ayer and Newport Creeks rather than the open tidal waters of Newport Bay itself based on 1998 data. In Newport Bay, Chlorophyll *a* concentrations were 50 micrograms per liter (Fg/l) or less under high flow (spring) and low flow (summer) conditions. The greatest algae populations were found in Trappe Creek where chlorophyll *a* concentrations from 100 to 200 Fg/l occurred during low flow conditions. Under high flow conditions in Trappe Creek, chlorophyll *a* concentrations as high as 125 Fg/l were measured. Ayer Creek and Newport Creek both exhibited elevated chlorophyll *a* concentrations during low flow conditions up to 125 Fg/l and up to 90 Fg/l respectively.



In Kitts Branch, chlorophyll *a* concentrations were consistently less than 40 Fg/l which indicates that algae is not a problem in this tributary.

Overall, the 1998 data suggests that the algae problem is related to conditions arising up in the watershed rather than from problems arising from tidal inputs from Sinepuxent or Chincoteague Bay.

2. Dissolved Oxygen

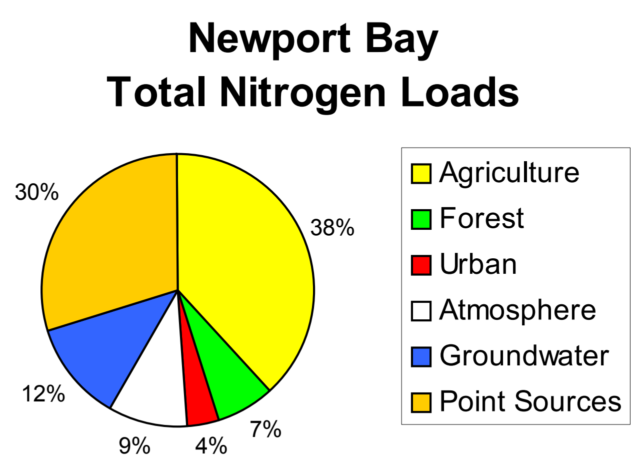
During spring high flow conditions, all the tidal waters monitored during 1998 exhibited dissolved oxygen concentrations that were consistent with the State water quality standard of 5.0 milligrams per liter (mg/l).[7] During summer months dissolved oxygen below the State standard was found in several areas:

– In Newport Bay, Newport Creek, Ayer Creek, Trappe Creek and Kitts Branch for all the tidal waters monitored in 1998. The lowest dissolved oxygen measurement, less than 2.5 mg/l, was observed in Ayer Creek.[7]
– Throughout Newport Bay (1999 through 2001 monitoring, DNR Resource Assessment Service)[18]
– Newport Creek and Marshall Creek (Aug. 2001 monitoring, DNR Resource Assessment Service)[18]
– Sinepuxent Bay (DNR Fisheries Service, sampling typically below a depth of 4 feet)[18]

3. Biological Oxygen Demand [7]

Biological Oxygen Demand (BOD) is a measure of oxygen consumption associated with living matter including algae, bacteria, plants and animals. BOD at various levels occurs naturally in water bodies and is only considered a problem if it causes problems such as violation of the 5.0 mg/l dissolved oxygen standard.

In most areas of Newport Bay system, low dissolved oxygen problems can be traced to algal activity and nutrients that feed the algae. However, 1998 monitoring of Kitts Branch found occasional low dissolved oxygen that was not accompanied by high algal activity. This suggests that BOD may be the cause.



4. Nitrogen In Tidal Waters [7]

Excessive levels of nitrogen were detected in1998 monitoring of the Newport Bay mainstem and Ayer and Newport Creeks at sites shown on Map 4 Monitoring Water Quality.

Modeling analysis conducted by MDE to support their TMDL work determined that nitrogen is the limiting nutrient in tidal waters of the Newport Bay system. This means that controlling nitrogen loads affecting tidal waters can effectively limit algae growth.

The relative sources of nitrogen loads to Newport Bay are shown in the adjacent pie chart adapted from MDE's TMDL report for Newport Bay. For total nitrogen, about two-thirds comes from point sources and agricultural lands based on MDE's estimates. Less than one-fifth of the nitrogen load comes from sources that are not locally controllable (groundwater and atmospheric deposition). Overall, these estimates suggest that control of locally generated nitrogen loads would reduce the total nitrogen load reaching Newport Bay.

5. Nitrogen in Nontidal Streams [20]

The United States Geological Survey (USGS) measured stream base flow and water quality in 17 nontidal streams discharging to Chincoteague, Newport and Sinepuxent Bays during the winters of 1999 and 2000. Map 4 Monitoring Water Quality shows the USGS monitoring sites that were within the WRAS project area.

USGS reports that the average stream base flow nitrate concentration for nontidal streams flowing into Maryland's Coastal Bays south of Berlin is 1.75 milligrams per liter (mg/l). Previously, nitrate concentration in this area was assumed be 0.72 mg/l. They also indicate that the majority of their samples found nitrate concentrations higher than natural levels for stream base flow in this area which is 0.4 mg/l or less. This finding indicates that the nonpoint contribution of nitrate to the Coastal Bays may be more significant than previously believed.

USGS also reports that base flow nitrate concentrations in streams ranged from below 0.5 to 5.28 mg/l as nitrogen. They found a significant positive correlation between the percentage of watershed area used for row crops and nitrate concentration. This finding indicates the nitrogen management for row crops is a significant contributor of nitrogen to the Coastal Bays.

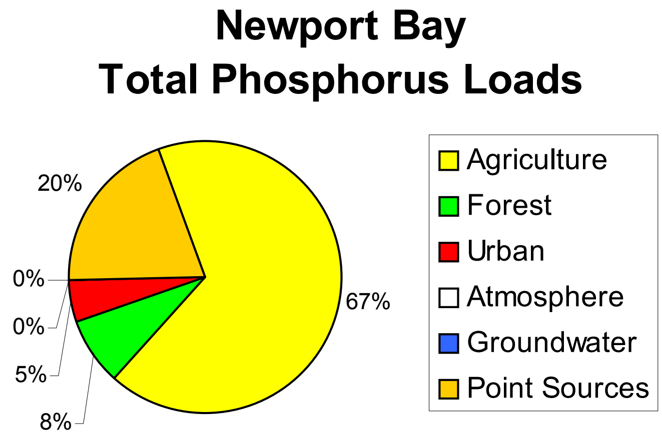
6. Nitrogen in Groundwater

US Geological Survey (USGS) reports that the dominant nutrients in groundwater for the Chincoteague Bay and Sinepuxent Bay vicinities are dissolved ammonia and dissolved nitrate. The highest ammonia concentrations, up to 23.4 mg/l as nitrogen, were associated with anoxic groundwater, i.e. well water with little or no dissolved oxygen. The highest nitrate concentrations, up to 15.5 mg/l, were associated oxic groundwater, i.e. well water that also contained dissolved oxygen. Nitrate concentrations ranged as low as 0.05 mg/l. These findings came from monitoring of 28 wells during the winters of 1999 and 2000. The wells were drilled into the surficial aquifer and the underlying confining layer so that water level and water quality measurements could be taken at different depths. [20]

USGS also sampled 388 wells in the Maryland Coastal Bays watershed to help map the distribution of groundwater nitrate concentration. Throughout most of the Newport Bay and Sinepuxent Bay watersheds, nitrate concentrations less than 1.0 mg/l were prevalent. However, several areas exhibited significantly higher nitrate concentrations. For example, nitrate concentrations in the 5.01 mg/l to 8.00 mg/l range characterized the area bounded by the tidal portion of Ayer Creek west, Newport Creek on the south and Sinepuxent Bay on the east.

7. Phosphorus

The 1998 monitoring described above was also the basis for assessing total phosphorus. As shown in the pie chart, phosphorus from agricultural lands (67%) and point sources (20%) dominate loads to Newport Bay according to MDE's estimates. Forest accounts for 8% and urban (developed) lands account for 5% of the phosphorus loads. Groundwater and atmospheric deposition, which are represented by "0%" labels on the pie chart, are not significant sources of phosphorus in the Newport Bay watershed. Based on this assessment, all sources of phosphorus are locally controllable.



8. Salinty

Based on monitoring in Newport Bay and Sinepuxent Bay in 2001 and 2002 during a study of macroalgae, the range of salinity in the two bays is similar, varying from about 27 parts per thousand (ppt) to 34 ppt.[19]

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 become mutually interdependent by employing vast transportation systems. All of this contributes to the decline in quality of our water and other natural resources.

1. 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.

The information from the Maryland Department of the Environment (MDE) permit data base for the Sinepuxent Bay and Newport Bay watershed is presented in two forms: MDE Discharge Permits Summary Table and Map 5 MDE Discharge Permits:

– The Sinepuxent Bay watershed has seven surface water discharges and three groundwater discharges of treated sewage affluent. Only one surface discharge, the Assateague National Seashore Visitors Center, may contribute significant nutrients to the Bay.

– The Newport Bay watershed has 13 surface water discharges. In 2003, the two most significant contributors of nitrogen to the Newport Bay system are the Berlin Wastewater Treatment Plant and Tyson Foods, Inc. Then, Tyson Foods closed its plant in 2003. Two lesser contributors are Kelly Foods, Inc. and the Newark Wastewater Treatment Plant. These four facilities may be affected by implementation of the nitrogen TMDLs in the Newport Bay watershed. The other nine surface water discharges in the watershed are not significant sources of nutrients.[7]

– Kitts Branch, where BOD was addressed in the TMDL, receives effluent from several significant point source dischargers. Before its closure in 2003, Tyson Foods, Inc. was the greatest BOD source. A lesser point source of BOD is Kelly Foods, Inc. During cold-weather months, the Berlin Wastewater Treatment Plant, which discharges to Bottle Branch/Kitts Branch only during the months of November through March, is the second greatest point source of BOD.

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

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.

A. Nutrients

According to the November 2002 TMDL report for Newport Bay, nonpoint source (NPS) nutrients, particularly nitrogen, are significant contributors to the use impairments in the Newport Bay system. On average for Newport Bay, 49% of the total nitrogen load arises from nonpoint sources (urban, residential and agricultural lands) and 80% of the total phosphorus load arises from nonpoint sources.

However, the relative importance of nonpoint source nutrient loads varies significantly among subwatersheds of the Newport Bay and Sinepuxent Bay area. For nitrogen, the Newport Bay watershed is dominated by nonpoint sources in all subwatersheds except Kitts Branch which has significant point source nitrogen loads. Phosphorus loads in all Newport Bay subwatersheds are entirely nonpoint sources except Kitts Branch which has significant point source nutrient loads.

MDE Discharge Permits Summary Table – Page 1 of 3 Sinepuxent Bay Watershed – All Permitted Discharges (2/2003 data)				
Type / MDE Category		**Facility**	**MD Permit / NPDES Permit**	**Receiving Stream / Watershed Street Location / Description**
Surface Water Discharge	Water Treatment	Mystic Harbour	99DP3071 MD0066923	Stephen Decatur Highway, Berlin drinking water treatment
Surface Water Discharge	Sewage Effluent	US Park Service	99DP2530 MD0021091	Assateague Island National Seashore Visitor Center
Surface Water Discharge	Industrial	UMES	03DP3422 MD0068977	Stephen Decatur Highway, Berlin Research Laboratory
Surface Water Discharge	Gen. Industrial Stormwater Permit	Ocean City Airport	97SW1001	Airport Road, Berlin airport stormwater
Surface Water Discharge	General Permits	Eagle's Nest Campground	01SI6247 MDG766247	Eagle's Nest Road, Berlin swimming pool discharge
Surface Water Discharge	General Permits	Frontier Town	01SI6002 MDG766002	Stephen Decatur Highway, Berlin swimming pool discharge
Surface Water Discharge	General Permits	Sunset Marina	02MA9230	Sunset Avenue, Ocean City
Groundwater Discharge	Sewage Effluent	Assateague Pointe	00DP2608	Stephen Decatur Highway, Berlin spray irrigation
Groundwater Discharge	Sewage Effluent	Mystic Harbour	99DP2273	Stephen Decatur Highway, Berlin groundwater injection permitted for 88,000 GPD
Groundwater Discharge	Sewage Effluent	The Landings	97DP0121	Rt 611, Berlin groundwater injection permitted for 100,000 GPD
KEY: GPD - gallons per day				

MDE Discharge Permits Summary Table – Page 2 of 3 Newport Bay Watershed – Surface Water Discharges (2/2003 data)			
Type / MDE Category	**Facility**	**MD Permit / NPDES Permit**	**Receiving Stream / Watershed Street Location / Description**
Sewage Effluent	Berlin WWTP	91DP0669 MD0022632	Bottle Branch Rd., Berlin 0.6 to 0.75 MGD current flow surface discharge Nov. 1 through Mar. 31, spray irrigation all other times.
	Newark WWTP	99DP0141 MD0020630	Worcester Highway, Newark, MD permitted for 70,000 GPD
Industrial	Kelly Foods Corp.	01DP0266 MD0001309	Old Ocean City Blvd., Berlin feed mill/pet food, permitted for 13,000 GPD 6,000 GPD current flow
	Ocean City Ice & Seafood	99DP1415 MD0055107	Washington St., Berlin ice production, about 1,500 GPD
	Tyson Foods, Inc.	90DP0375 MD0002071	Old Ocean City Blvd., Berlin chicken processing - facility closed
Gen. Industrial Stormwater Permit	Perdue Farms, Inc.	97SW0303	Bryan St., Berlin stormwater from feed mill area
	SHA Berlin Shop	97SW1311	Berlin Highway, Berlin stormwater from equipment yard
	Berlin Power Plant	97SW0615	William Street, Berlin stormwater from utility facility
	Tyson Foods, Inc.	02SW0914	Old Ocean City Blvd, Berlin stormwater from industrial facility
General Permits	Delmarva Oil	2003OGR3124 MDG913124	Harrison Ave., Berlin bulk petroleum
	Delmarva Oil	2003OGT3124 MDG343124	Harrison Ave., Berlin bulk petroleum
	Berlin Water Dept.	00HT9405 MDG679405	William St., Berlin drinking water treatment discharge
	Rayne's Sand and Gravel	00MM9808 MDG499808	Worcester Highway, Berlin permitted for 10,000 GPD

MDE Discharge Permits Summary Table – Page 3 of 3 Newport Bay Watershed – Groundwater Discharges (2/2003 data)			
Type / MDE Category	**Facility**	**MD Permit / NPDES Permit**	**Receiving Stream / Watershed Street Location / Description**
Sewage Effluent	Mariner's Country Downs	00DP3138	Sinepuxent Road, Berlin spray irrigation, permitted for 11,000 GPD
Industrial Effluent	Barrett Chev/Olds	97DP2392	Barnett Road, Berlin car wash at dealership
	Merial Select	00DP0369	Main St., Berlin, pharmacy plant
	Sherwood Ford/Mercury	98DP2474	Worcester Highway, Berlin spray irrigation of car wash water
KEY: GPD - gallons per day			

B. 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 interferes with these natural processes by attempting 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 shoreline for both the Coastal Bays and the Chesapeake Bay drainage. [8]

Worcester 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
407	919 (32%)	74	26	10

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 Worcester 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 and address 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: St. Mary's County and Dorchester County. Results from this work are not currently available.

Groundwater and Water Supply

In the Newport Bay and Sinepuxent Bay watersheds, groundwater is the source of nearly all water used for agriculture and business, and all potable water including community systems of water supply and distribution. In general, these water uses do not employ near-surface groundwater, which is subject to potential local pollution sources. Additionally, near surface groundwater is credited with carrying nutrients, particularly nitrogen, from land source to surface waters where nutrient over-enrichment is occurring.

As shown on Map 6 Community Water Systems, several public water supply systems are located in the Newport Bay watershed and none are located in the Sinepuxent Bay watershed. Permit information is summarized in the table below.

Community Water Systems in the Newport Bay Watershed		
Source	**Facility Name**	**Permit Number**
Groundwater	Berlin, Town Of	WO1980G004
	Briddletown	WO1986G026
	Sunset Lakes Mobile Home Park	WO1986G008
	Tom All Apartments	WO1978G006

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 either 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 Newport Bay and Sinepuxent Bay watersheds from the 1998 Plan, with the exception of the Year 2000 population density estimates.

Summary of Coastal Bays Landscape Indicators

Watershed	Population Density (people/acre)	Wetland Loss (acre)	Unbuffered Streams (percent)	Soil Erodibility (value/acre)
Assawoman Bay	0.65	3,531	61	0.13
Isle of Wight Bay	0.57	16,129	44	0.23
Sinepuxent Bay	0.25	2,662	79	0.13
Newport Bay	0.22	17,025	25	0.08
Chincoteague Bay	0.03	28,820	26	0.13

Color Key: Green- benchmark met, conditions better than some other comparable watersheds. Orange- benchmark not met, condition is poorer than many other comparable watersheds.

1. Population Density

The Year 2000 population density in the Newport Bay and Sinepuxent Bay watersheds was 0.22 and 0.25 people per acre of land respectively. A comparison with other watersheds in Maryland 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 Newport Bay and Sinepuxent Bay watersheds are estimated to have lost about 2,662 and 17,025 acres of wetlands, respectively, over the years.[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

Newport Bay and Sinepuxent Bay watersheds differ significantly on the extent of unbuffered streams, 79% and 25% respectively based on 1998 information. To develop this indicator, the presence or absence of forest cover adjacent to streams in corridors 100 feet wide (50 feet either side of the stream) was assessed. The 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]

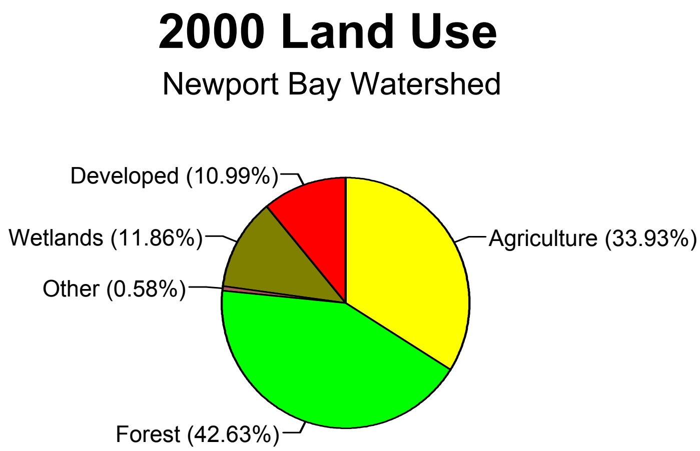
In most of Maryland, trees are key to healthy natural streams. They provide numerous essential habitat functions: shade to keep water temperatures down in warm months, leaf litter "food" for aquatic organisms, roots to stabilize stream banks, vegetative cover for wildlife, etc. In general, reduction or loss of riparian trees in stream buffers degrades stream habitat while replacement of trees to create natural stream buffers enhances stream habitat. For this indicator, only streams that are shown on USGS Quadrangle maps are addressed.

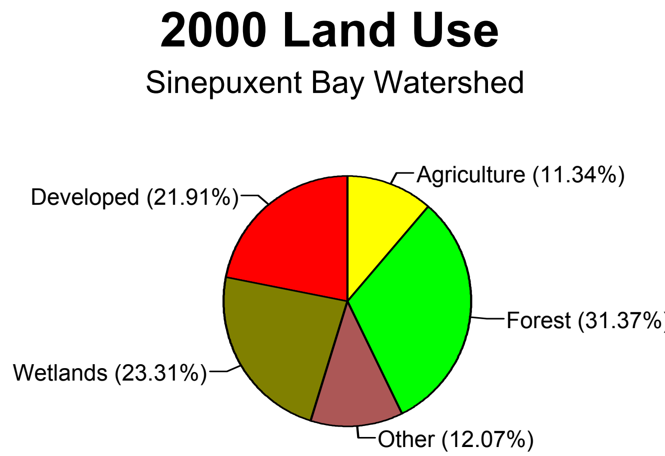
4. Soil Erodibility

Soil erodibility for Newport Bay and Sinepuxent Bay watersheds are both in the range of very low erosion potential as measured by the K factor: 0.13 and 0.08 respectively.[2] The K factor normally varies from approximately zero to about 0.6. A 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.

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 pie charts above and table below summarize Year 2000 data for the Newport Bay and Sinepuxent Bay watersheds as categorized by the Maryland Department of Planning. Map 7 Land Use / Land Cover shows the distribution of these land uses in the watershed.

In general, the forest and brush cover the greatest percentage of land in both the Newport Bay watershed and the Sinepuxent Bay watershed. 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.

Land Use / Land Cover Summary Table
Sinepuxent Bay and Newport Bay Watersheds, MDP 2000 Data, Acres / Percent

Subwatershed Name / Number		Ag	Forest & Brush	Developed	Wetland	Other Land	Total Land
Sinepuxent Bay		851 11%	2,354 32%	1644 22%	1,749 23%	906 12%	7,504
Newport Bay	Trappe Creek Headwaters	1,262 33%	1,355 33%	1,425 34%	6 --	75 --	4,123
	Ayer Creek & Trappe Creek	2,550 37%	3,164 46%	386 6%	774 11%	3 --	6,877
	Newport and Porter Creeks	3,523 33%	4,277 40%	989 9%	1,763 17%	80 1%	10,632
	Marshall Creek	1,905 34%	2,813 51%	192 3%	687 12%	-- --	5,597
	Newport Bay Total	9,240	11,609	2,992	3,230	158	27,229

Impervious Surface

Upstream Impervious Cover Thresholds And 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.

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 as the table above shows. 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 nonpoint source pollution, higher temperatures, reduced stream baseflow and more erosive flood flow.

Map 8 Impervious Surface Newport Bay and Sinepuxent Bay Watersheds and the table below reflects data developed by the University of Maryland's Regional Earth Sciences Application Center (RESAC).[10] The map shows relative average impervious cover for each subwatershed and it shows local concentrations of impervious coverage as darker areas. The map also shows that the subwatersheds closest to Route 50 have the highest average impervious cover (Sinepuxent Bay, Trappe Creek Headwaters, Ayer and Trappe Creeks). The subwatersheds south of Berlin have very low average impervious surface.

Map 9 Impervious Cover Town of Berlin Vicinity shows the distribution of impervious surface around the most developed portion of the Newport Bay watershed. At this scale, it is possible to see that the majority of the area has little impervious surface. However, concentrations of impervious cover in and around Berlin and adjacent to major roads may have significant affect on local waterways. The findings presented in the maps suggest potential directions for watershed management activities:

– Large areas of the WRAS project watershed probably have very little impact from impervious surfaces. These areas could be prioritized for controls on new impervious surface or other forms of protection. In these areas, if any restoration action is needed, relatively limited restoration projects may be able to eliminate impacts associated with impervious surfaces.
– Limited areas near Berlin and major roads, where impervious surface is concentrated, could be prioritized for protects like stormwater infiltration retrofits.

Average Subwatershed Imperviousness	
Subwatershed Name	**Percent**
Sinepuxent Bay	3.6
Trappe Creek Headwaters	9.85
Ayer and Trappe Creeks	2.2
Newport and Porter Creeks	1.45
Marshall Creek	0.9

Color Key for average imperviousness:
Green- less than 2%; Yellow- 2% to 10%

Lands With Significant Natural Resource Value and Large Area

1. Green Infrastructure

DNR has mapped a network of ecologically important lands, comprised of hubs and linking corridors, using several GIS data layers to identify hubs that contain one or more of the following:
- 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 www.dnr.maryland.gov/greenways/

Protection of Green Infrastructure lands may be addressed through various existing programs including Rural Legacy, Program Open Space, conservation easements and others.

Map 10 Green Infrastructure shows that, even from the statewide perspective that guided the analysis, there is a significant amount of Green Infrastructure in the Newport Bay and Sinepuxent Bay watersheds. Assateague Island is the only Green Infrastructure hub where natural resource values are protected. Other Green Infrastructure hubs are not protected.

2. Large Forest Blocks

Large blocks of forest provide habitat for species that are specialized for conditions with relatively little influence by species from open areas or humans. For example, forest interior dwelling birds require forest interior habitat for their survival and they cannot tolerate much human presence. Map 11 Forest Interior shows blocks of contiguous forest that are at least 50 acres in size with at least 10 acres of forest interior (forest edge is at least 300 feet away) that may be important locally within the Newport Bay and Sinepuxent Bay watersheds. 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 11 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.

Protected Lands

Protected land is any land with some long term limitation on conversion to developed land use. This protection may be in various forms like public ownership or private ownership where a third party acquired the development rights or limits use through an easement. The extent of protection varies from one circumstance to the next and it is necessary to know the details parcel by parcel through the local land records office to determine the true extent of protection.

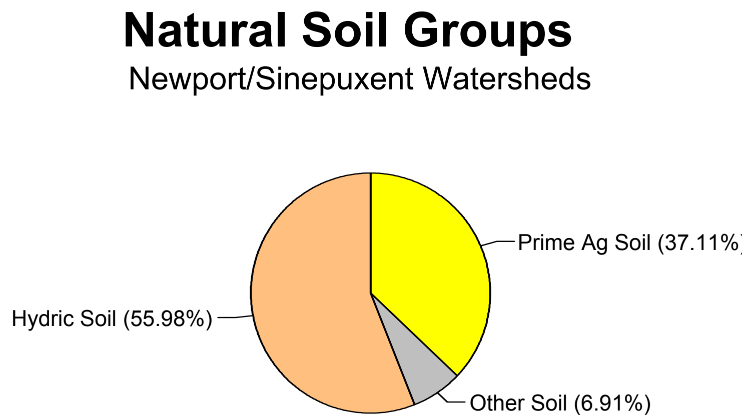
Map 12 Protected Land shows the distribution of protected lands. The table shows that the two watersheds together have over 2,600 acres of park. Most of this is National Seashore and State Park in on the barrier island. Also, there are over 400 acres of easements that limit uses for conservation or agricultural purposes.

Summary for Land Protection and Priority Funding Area		Newport Bay		Sinepuxent	
		Acres	%	Acres	%
Park	National	--	--	1,538	20
	State	--	--	939	13
	County	78	#1	64	#1
	Total Park Land	78	#1	2,541	34
Easement	Agricultural	199	#1	--	--
	Conservation (MET)	--	--	18	#1
	Forest Conservation	62	#1	111	1
	Wetland Reserve	21	#1	--	--
	Total Easements	282	2	129	2
Other	Development Rights Purchased by State	2,409	18	--	--
Watershed Land Total		13,711	100	7,504	100
NOTE: Some County and State park land is also under forest conservation easement.					

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. Map 13 Soils shows soil variation in the Newport Bay and Sinepuxent Bay watersheds. The table and pie chart summarized information from the map.



Natural Soil Group Summary for Newport Bay and Sinepuxent Bay Watersheds

Soil Group	Soil Group Description	Acres	Total %	Total Acres
Prime Agricultural Soils	B1a - Well drained, moderate erodibility.	10,577	37.11	13,231
	E1 - Moderately well drained, low erodibillity.	1,537		
	E3a - Moderately well drained, high erodibility.	1,117		
Soils With Various Limitations for Farming	A1a - Sandy, excessively well drained	586	6.91	2,464
	A2, A2a - Sandy, loose and not coherent - beach	1,274		
	BP - Borrow pit (sand and gravel mine, etc.)	357		
	Ma - Made land	247		
Hydric Soils	F1 - Sandy, very wet.	283	55.98	19,956
	F2 - Poorly or very poorly drained, strongly to extremely acid, low erodibility.	9,358		
	F3 - Hydric, clayey, very high erodibility	4,384		
	G2 - Poorly drained floodplain, seasonally wet	742		
	G3 - Marsh and swamp	5,190		

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 Map13 Soils with the other maps listed below, it may be possible to discern how patterns of active or passive land use relate to soil conditions:

– Map 7 Land Use / Land Cover
– Map 10 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. Once areas of interest are targeted and landowner interest is verified, additional detailed soil assessment is an essential step in identifying viable restoration project sites.

Floodplains And Low Elevation Areas Subject To Sea Level Rise

The average rate of sea level rise along Maryland's coastline has been 3-4 mm/yr or approximately one foot per century. Such rates are nearly twice those of the global average (1.8 mm/yr), a result most likely influenced from land subsidence. The rate of sea level rise is expected to accelerate in response to global warming, resulting in a rise of 2-3 feet by the year 2100.

The low-lying coastal plains such as those along the eastern shore are vulnerable to impacts associate with rising sea level. Sea level rise threatens to exacerbate erosion and flooding, making areas more vulnerable to land loss, permanent inundation, and storm surge. Recognizing the need for advanced planning, DNR developed a response strategy in 2000 and is acquiring high-resolution elevation data (LIDAR) in the most vulnerable areas. Complete coverage of Worcester County including the Sinepuxent and Newport Bay has been acquired and select areas were defined as being less than 1.5 meters (5 feet) above sea level. Accurate elevation data will significantly improve the State and County's ability to define the most vulnerable areas and determine the most appropriate management measures to mitigate the impacts.

Map 14 Floodplains shows the 100-year floodplain extending over a majority of the land near open water in the Sinepuxent Bay and Newport Bay. Small areas of floodplain also occur along the tributaries to Trappe Creek in the vicinity of the Town of Berlin. As sea level rises and land development increases, the 100-year floodplain is likely to expand putting more infrastructure and resources at risk from permanent inundation and flooding.

Wetlands

1. Wetland Categories

The Coastal Plain Province 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.

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 Newport Bay and Sinepuxent Bay watersheds. 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.)

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 increase of wetland acreage in the Sinepuxent Bay watershed over the past 11 years. A small net decrease occurred in the Newport Bay watershed. This slowing of wetland loss in the watershed contrasts significantly with the estimated historic wetland loss in the watershed as described in the Landscape Indicators section.

Tracking Nontidal Wetland Change In The Newport Bay/Sinepuxent Bay Watersheds In Acres 1/1/1991 through 12/31/2002 [11]						
Basin Code	**Watershed**	**Permanent Impacts**	**Permittee Mitigation**	**Programmatic Gains**	**Other Gains**	**Net**
02130104	Sinepuxent Bay	-3.67	3.11	3.00	0.09	2.53
02130105	Newport Bay	-4.80	3.45	0.50	0.80	-0.05

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 for each watershed includes the entire watershed and it is not normalized.
2) "Permanent Impacts" refers to acres altered (e.g., filled, drained) under permit from MDE.
3) "Permittee Mitigation": acres restored by a permit holder as required by MDE permit.
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": acres of wetlands restored when not required as mitigation for permitted losses.

3. Interpreting Wetland Distribution

Map 15 Wetlands and the table below summarize distribution and categories of wetlands in the WRAS area. In the Newport Bay watershed, 94% of wetlands are emergent estuarine or forested palustrine. The Sinepuxent Bay watershed is dominated by three wetland types: estuarine emergent 43%, unconsolidated shore (beach) 40% and forested palustrine 11%.

Wetland Acreage Summary: Newport Bay and Sinepuxent Bay Watersheds				
Wetland Class		Area In Acres		
		Newport Bay	Sinepuxent Bay	Total
Estuarine	emergent	3,272	1,711	4,983
	forested	2	13	15
	scrub shrub	9	106	115
	unconsolidated bottom	8	28	36
	unconsolidated shore	37	1,596	1,633
Lacustrine	unconsolidated bottom	68	0	68
Palustrine	emergent	46	56	102
	forested	2,872	453	3,325
	scrub shrub	96	10	106
	unconsolidated bottom	139	18	157
Total Wetlands (DNR mapped wetlands)		6,549	3,991	10,540

LIVING RESOURCES AND HABITAT

Living resources, including all the animals, plants and other organisms that call the land and waters of the Newport Bay and Sinepuxent Bay watersheds 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 or referenced 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 one living resource indicator for the Newport Bay watershed and did not present any for the Sinepuxent Bay watershed.[2]

For the Newport Bay watershed, score of 3.2 for Nontidal Benthic Index of Biotic Integrity (IBI) indicates that the benchmark set was not met. This indicator 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.

Fish and Oysters

1. Fish In Nontidal Streams

Information on fish in nontidal streams has been gathered as part of the Maryland Biological Stream Survey (MBSS) for one stream in the Newport Bay watershed. The table shows that all the fish species identified are either tolerant or moderately tolerant of pollution and/or poor habitat conditions. The ranking of pollution tolerance is taken from work associated with MBSS.[15]

Fish in Kitts Branch – MBSS 2001 Data	
Tolerant Species Fish that tend to survive greater pollution and poorer habitat conditions	**Moderately Tolerant Species** Fish with mid-range ability to co-exist with pollution and varied habitat conditions
American Eel	Banded Killfish
Bluegill*	Inland Silverside
Eastern Mudminnow	Largemouth Bass*
	Mosquitofish
	Pumpkinseed
* See Fish Consumption Advisory regarding the methylmercury found in these fish.	

2. Oysters

Oysters were once an important regional fishery but have declined drastically during the twentieth century due to harvesting, disease and predation.[16] Early in the century, natural oysters bars were found in Maryland's Coastal Bays according to a survey of oyster beds by C.C. Yates conducted between 1906 and 1912. As shown on Map 16 MBSS Sampling Sites and Oyster Status, about half of one 129-acre historic oyster bed was located within Newport Bay as it is currently delineated.[17]

Currently, no legally designated oyster beds are located in Maryland's Coastal Bays, including Newport Bay and Sinepuxent Bay. Oyster lease areas are currently located in the Assawoman Bay, Sinepuxent Bay and Chincoteague Bay. The only oyster lease in the WRAS area, in Sinepuxent Bay, covers about 1.5 acres as shown on Map 16 MBSS Sampling Sites and Oyster Status.

3. Tidal Fisheries

Immediately available information on tidal fisheries does not segregate data on Newport Bay or Sinepuxent Bay. However, the following information that represents all of Maryland's Coastal Bays can be used as a frame of reference for the WRAS project area:

– Blue crabs comprise the most valuable commercial fishery product from Maryland's Coastal Bays. Due to high salinity in these bays, blue crabs are relatively small compared to their Chesapeake Bay counterparts. According to DNR trawl survey results, only 5% of the blue crabs inspected are greater than five inches across while 21% of Chesapeake Bay blue crabs are over five inches. [23]

– In 2002 surveys conducted by DNR, 80 species of fish were identified. In the prior 30 years of surveys, an additional 50 species have also been identified. Twenty of the species identified in 2002 included juveniles. The Coastal Bays serve as important nursery areas for these species. [23]

- Four fish species are highly abundant in Maryland's Coastal Bays: Atlantic menhaden, Atlantic silverside, spot and bay anchovy. These fish are important forage for other fish species that are valued for commercial and recreational purposes. [23]
- Adults of many fish species are seasonally common in Maryland's Coastal Bays: summer and winter flounder, weakfish, bluefish, croaker, white perch, spot, black sea bass, tautog, eel and sharks.[24]
- Recreational catches for some fish species are significant: summer flounder, weakfish, bluefish, croaker, tautog, striped bass and black sea bass.[24]
- Some of the important fish species in Maryland's Coastal Bays have declined in population over time. This has necessitated management the affects to address the decline:[25]
  - Between the early 1970s and 1999, a coastal bay forage index based on Atlantic menhaden, spot, bay anchovy and Atlantic silverside has shown a gradual decline.
  - Summer flounder has strict harvest controls that were set after severe declines in the late 1980s. Increases in recruitment are evident based on presence of coastal bay juveniles and increasing average size in the offshore population.
  - Atlantic croaker has exhibited variable population size that may be associated with weather conditions and harvest rate. Stocks are showing consistent improvement which is attributed to current restrictions and bycatch reduction devices in commercial nets.
  - Spot have declined substantially since the late 1980s. The causes of this change is not understood. Spot is valuable for both commercial and recreational interests and as a forage species for game fish.
  - Bluefish was a major sportfish as late as 1989 but has exhibited substantial decline since that time.
  - Black sea bass is at a low biomass level and is believed to be over-exploited. In the late 1990s, the average size in the population increased which suggests the potential for a trend toward recovery.

Benthic Macroinvertebrates In Nontidal Streams

During the past 25 years, DNR has conducted biological assessment of selected stream sites in the Newport Bay watershed using three different methods. Map 16 MBSS Sampling Sites and Oyster Status shows sampling sites were data is available. The Maryland Biological Stream Survey (MBSS) samples stream conditions for fish, benthic population and habitat conditions. Rresults from this sampling are summarized in the table below. Also see http://www.dnr.maryland.gov/streams/mbss/index.html. (Click on "Search Online Data" and search for "Newport Bay or Sinepuxent Bay under "8 Digit watershed name").

2001 MBSS Findings in the Newport Bay Watershed				
Location	Station #	Score		
		Fish	Benthos	Physical
Kitts Branch	NEWP-116-R-2001	3.0	2.71	--
Bassett Cr. / Tukesburg Branch	NEWP-110-R-2001	--	1.29	--

Key for MBSS Findings Table					
Index of Biotic Integrity Ranges		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

Prior to creation of the MBSS method of assessment and random site selection technique, DNR used other biological assessment approaches in nontidal steams known as artificial substrate samplers and rapid bio-assessment. While results of these assessment techniques are not directly comparable to the MBSS method, they do provide a way to compare stream conditions during the early 1990s. Information from these efforts is summarized in the text that follows.

1. Bottle Branch at Harrison Road

In 1994 and 1996, sampling of benthic macroinvertebrates in Bottle Branch at Harrison Road was conducted using the rapid bioassessment technique. The following ratings summarize the findings: Benthic community quality – poor; Habitat quality – poor; Water quality – fair.

Since 1978, DNR has sampled macroinvertebrates in Bottle Branch at the Harrison Road crossing using artificial substrate samplers. Assessment of the benthic community shows a significant improvement in species diversity and a shift in species type, which together indicate that conditions have improved at this site over the past 25 years. Most of the improvement has occurred since 1997.

The data shows that there was a significant correlation between time and biotic index and taxa number, with both improving. The taxa number is the total number of genera found at the site at the time of sampling. It reflects the health of the community but a direct measure of the types of organisms and the number will increase with better water quality and better suitability for the organisms. The biotic index is used to detect organic pollution and its influence on the macroinvertebrate community. When it improves it means that there are more pollution intolerant organisms present and less pollution tolerant. The macroinvertebrate community showed that over the years the site has been sampled that the water quality went from the upper poor range to the lower fair range, which is considered a moderate improvement in the water quality.

2. Kitts Branch at Flower Road

In 1990, 1994 and 1996, sampling of benthic macroinvertebrates in Kitts Branch at Flower Road was conducted using the rapid bioassessment technique. The following ratings summarize the findings. Comments listed with the data indicate that the stream channel was ditched and a discharge from poultry plant was evident: Benthic community quality – poor; Habitat quality – poor; Water quality – poor.

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 invertegrates are sometimes called "stream bugs" though that name overly simplifies the diverse membership of this group. This group includes mayflies, caddisflies, crayfish, and other invertebrates, 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.

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. The table, Sensitive Species Tracked By Maryland in the Newport Bay and Sinepuxent Bay Watersheds, lists animals and plants of concern within the WRAS project area.

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.

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 17 Sensitive Species, three specific sensitive species overlays used by the State of Maryland are found in the Newport Bay and Sinepuxent Bay watersheds. 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 are designed to serve as coarse filters. To allow for uncertainty pertaining to interpretation discrepancies, the polygons used on the map to depict these locations have been buffered. 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 and habitat within their ownership.

Sensitive Species Tracked By Maryland In The Newport Bay And Sinepuxent Bay Watersheds			
	Scientific Name	**Common Name**	**Status**
Animals	Charadrius melodus	Piping plover	Md. Endangered, US Threatened
	Cicindela dorsalis media	White tiger beetle	Md. Endangered
	Haliaeetus leucocephalus	Bald eagle	Md. Endangered, US Threatened
	Rynchops niger	Black skimmer	Md. Threatened
	Sterna antillarum	Least tern	Md. Threatened
Plants	Almus maritima	Seaside Alder	Other
	Antennaria solitaria	Single-headed pussytoes	Md. Threatened
	Asclepias rubra	Red milkweed	Md. Endangered
	Carex silicea	Sea-beach sedge	Md. Endangered
	Cleistes divaricata	Spreading pogonia	Md. Endangered
	Cyperus retrofractus	Rough cyperus	Other
	Dryopteris celsa	Log fern	Md. Threatened
	Eleocharis albida	White spikerush	Md. Endangered
	Eleocharis rostellata	Beaked spikerush	Other
	Fimbristylis caroliniana	Carolina fimbry	Other
	Fuirena pumila	Smooth fuirena	Other
	Gymnopogon brevifolius	Broad-leaved beardgrass	Md. Endangered
	Ludwigia hirtella	Hairy ludwigia	Md. Endangered
	Panicum scabriusculum	Tall swamp panicgrass	Md. Endangered
	Polygonum glaucum	Seaside knotweed	Md. Endangered
	Prunus maritima	Beach plum	Md. Endangered
	Scleria verticillata	Whorled nutrush	Md. Endangered
	Sesuvium maritimum	Sea-purslane	Md. Endangered
	Spiranthes praecox	Grass-leaved ladys' tres	Other
	Triglochin striata	Three-ribbed arrow-grass	Md. Endangered
Note: “Other” means that this uncommon species is tracked to aid in conserving its habitat in Maryland.			

Sensitive Species Protection Areas In the Newport Bay and Sinepuxent Bay Watersheds

Ecologically Sensitive Area (ESA)

At least nine ESAs are identified in the Newport Bay and Sinepuxent Bay watersheds as shown in Map 17 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)

As shown in Map 17 Sensitive Species, there is one NHA in the Sinepuxent Bay watershed and none are in the Newport Bay watershed. It covers the entire Assateague Island National Seashore. 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 potentially 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)

As shown on Map 17 Sensitive Species, numerous WSSCs, totaling about 57 acres, are designated in the Newport Bay Watershed. These important and ecologically unique wetlands are mostly located between Bassett Creek and Porter Creek. There are no WSSCs in the Sinepuxent Bay watershed. 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 EA 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

Seaweed / Macroalgae

Macroalgae, commonly called seaweed, are the simple aquatic plants that grow in shallow high salinity aquatic environments like the Coastal Bays. A two-year study beginning in 1998 was the first to characterize macroalgae in Newport Bay and Sinepuxent Bay. A random sampling technique used throughout the Coastal Bays of Maryland and Delaware, found that macroalgae are more abundant that previously suspected and that no significant difference in abundance among embayments was detected.

A second study conducted in May, August and November 2001 and March 2002 assessed over 600 monitoring sites in Maryland's Coastal Bays returned several findings in the WRAS area:[19]

– The objective of the study was to determine if there is a relationship between nutrient enrichment and the relative abundance of phytoplankton (associated with high nutrients), macroalgae (associated with mid-range nutrients) and SAV (associated with low nutrients). The study did not establish the presence or absence of a correlation. However, considering only the WRAS project area, its findings for Newport Bay (higher nurients and Chlorophyll *a*, less macroalgae and SAV) and Sinepuxent Bay (lower nutrients and Chlorophyll *a*, more macroalgae and SAV) are consistent with the hypothesis.

– Red algae was the most diverse group identified by the study. These algae are commercially grown as a source of ingredients for food, cosmetics and medicines. The most common group, known as red weeds (genera *Agardhiella* and *Gracilaria*), were well distributed throughout the bays in all seasons except for Newport Bay where their presence was limited to spring.

– Green macroalgae was the second most diverse group found and sea lettuce (*Ulva spp.*) was the most prevalent. It was generally distributed throughout the Coastal Bays and was most consistently found in Sinepuxent Bay and in embayments to its north. In Newport Bay, these macroalgae were consistently absent.

– Brown algae was a less diverse group than either green or red macroalgae. Brown algae in one form of another was found in Sinepuxent Bay during all seasons but no genera was present year-round. In Newport Bay, brown algae is generally absent but appears in winter/spring in the south end of the bay.

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 the 1930s, a disease nearly eliminated all SAV in Maryland's Coastal Bays. Since about 1986, in general there has been a steady increase in area covered by SAV beds. For example SAV acreage increased from 2000 to 2001 in most Coastal Bay Areas. However, a few areas including Sinepuxent Bay experienced a decrease in SAV acreage from 2000 to 2001. Coverage in Sinepuxent Bay decreased approximately 2 percent from 2000 to a total of 1,654 acres in 2001.[13]

SAV Acreage for Selected Years		
Year	**Newport**	**Sinepuxent**
1999	52	1,925
1998	66	1,463
1997	68	1,264
1996	19	1,058
1995	23	718
1989	0	425

The size of SAV beds in Sinepuxent Bay has been generally consistent with the Coastal Bays-wide trend toward increasing acreage covered based on data collected since1989 as shown in the adjacent table. Map 18 Submerged Aquatic Vegetation also shows the difference in area covered in 1989 versus 1999.

In Newport Bay, the adjacent table shows that SAV beds have covered a relatively small acreage and the trend toward increasing acreage is less pronounced. In general, SAV beds large enough to be identified via aerial photography have always been limited to the eastern bank of Newport Bay.

For additional information, also see http://www.dnr.maryland.gov/bay/sav/index.html .

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. Some of these tools are described below.

2003 Stream Assessments Conducted By DNR

During 2003 in partnership with Worcester County, DNR conducted two types of assessment of selected streams in the Newport Bay and Sinepuxent Bay watersheds. The reports are available at www.dnr.maryland.gov/watersheds/surf/proj/wras.html.

A Stream Corridor Assessment focused on several subwatersheds selected by Worcester 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 Worcester 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 Worcester SCD and Natural Resource Conservation Service (NRCS). [28]

Marina Programs

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.

According to DNR's Marina database, there are 24 marinas in Worcester County. One marina serves Newport Bay and four serve Sinepuxent Bay. Map 19 Marinas shows their approximate location. Curently, pumpout facilities are offered by one marina within the Sinepuxent Bay watershed and by several marinas closer to Ocean City. Two of the marinas in Worcester County currently participate in Maryland's Clean Marina Program but none of these are in the WRAS project area.

The Clean Marinas Program is a way for marina owners to gain certification and public recognition for voluntarily adopting marina design, operation, and maintenance practices intended to properly manage all kinds of marine products and activities, and to reduce and properly manage waste. DNR also funds installation and maintenance of marine pumpout facilities, including those at certified Clean Marinas. (See www.dnr.maryland.gov/boating for details.)

Stream Buffer Restoration

1. Progress [22]

Map 20 Stream Buffer Scenario and the table show that stream buffer projects in at least 10 areas between 1996 and 2001 in the Newport Bay and Sinepuxent Bay watersheds. (DNR Forest Service data.)

Riparian Forest Buffer Creation Maryland Coastal Bays 1996 - 2001			
Watershed	Length (ft.)	Average Width (ft.)	Acres
Assawoman	8,300	120	22
Isle of Wight	7,198	161	30.9
Sinepuxent	**5,412**	**210**	**20.5**
Newport	**14,880**	**126**	**46.4**
Chincoteague	78,925	160	246.5
Total	114,715	--	366.3

2. Benefits and General Recommendations

Natural vegetation in stream riparian zones, particularly forest, provides numerous valuable environmental benefits:

– Reducing surface runoff and 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.

3. 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.

4. Land Use / 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 as shown in the adjacent table. By restoring naturally vegetated stream buffers adjacent to lands producing the highest pollutant loads, nutrient and sediment loads can be reduced most efficiently. Map 20 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

5. Nutrient Uptake from Hydric Soils in Stream Buffers

In general, the nutrient nitrogen moves from the land into streams in surface water runoff

and in groundwater. In watersheds like the Newport Bay and Sinepuxent Bay 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 20 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. For example, some areas identified on the map (north and east of Berlin) appear to be dense networks of ditching to serve agricultural fields. Creating naturally vegetated stream buffers in such areas is probably only practical if the land owner is no longer interested in using the area for crops.

6. Optimizing Water Quality Benefits by Combining Priorities

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

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

Additionally, selecting restoration projects that are likely to produce measurable success is an important consideration in prioritizing projects for implementation. In 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.

In early 2004, the Maryland Department of the Environment will release an extensive assessment of wetland restoration opportunities in a report to be entitled "Prioirty Areas for Wetland Restoration, Preservation, and Mitigation in Maryland's Coastal Bays".[26] It is anticipated that MDE's work will offer a number of ways to approach the issue of preventing loss of wetlands and enhancing wetland resources in and around the Newport Bay and Sinepuxent Bay watersheds.

Using already available data, one approach to identifying candidate wetland restoration sites uses GIS to help identify "historic" wetland areas based on the presence of hydric soils. Map 21 Wetland Restoration Scenario indicates that there appears to be potential for wetland restoration based on identifying crop land and/or pasture on hydric soil within 50 of existing wetlands. This is one of many potential scenarios for finding opportunities for wetland restoration. The steps and priorities used to generate the map scenario are listed below:

– Data used: Hydric soils (SSURGO), 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 existing 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.

REFERENCES

1. Maryland DNR. *Internet Site:* http://www.dnr.maryland.gov Source areas from the site: *Surf Your Watershed; Chesapeake Bay Tributary Strategies; Information Resource Center / Publications / Data.* Accessed November 2003.
2. Clean Water Action Plan Technical Workgroup. *Maryland Clean Water Action Plan.* December 1998. www.dnr.maryland.gov/cwap/ Accessed November 2003.
3. Department of State Documents Internet Site: www.dsd.state.md.us
4.MDE. Maryland's 303(D) lists: *1996 303(d) List of Water Quality Limited Basin Segements*, or *1998 Additions to Maryland's 303(d) List*, or *Draft Maryland's 2000 303(d) List.* For Internet access, go to www.mde.state.md.us, search for "impairment" and go to either 2002 303 or 303(d) List. Internet site accessed November 2003.
5. MDE. www.mde.state.md.us/tmdl/ Accessed November 2003.
6. National Academy of Sciences. *Clean Coastal Waters: Understanding and Reducing The Effects of Nutrient Pollution.* National Academy Press. 2000.
7. MDE. *Total Maximum Daily Loads of Nitrogen for Three Tidal Tributaries and Total Maximum Daily Load of Biological Oxygen Demand for One Tributary in the Newport Bay System.* November 2002. 64 pages.
8. Maryland Shore Erosion Task Force. *Final Report, State of Maryland Shore Erosion Task Force.* January 2000. 67 pages.
9. Johnson, Zoë Pfahl. *A Sea Level Rise Response Strategy For The State Of Maryland.* Document was prepared for Maryland DNR Coastal Zone Management Division. October 2000. 49 pages.
10. Maryland Dept. of the Environment Water Supply Program. 2003 information.
11. MDE. *Nontidal Wetland Impact Data By Watershed Segment (In Acres) 01/01/1991 - 12/31/2002.* Received via fax from Kelly Neff, Maryland Dept. of the Environment June 26, 2003. Five pages.
12. Friedman, Ellen. Personal communication. Department of Natural Resources Resource Assessment Services/Monitoring and Nontidal Assessment. May 22, 2003.
13. Maryland DNR. *Latest Bay Grass Survey Shows Increases In Maryland's Coastal Bays*. Press release issued February 12, 2003.
14. Homer, M.L., M. Tarnowski, and L. Baylis. A Shellfish Inventory of Chincoteague Bay, Maryland. Final Report to Coastal and Watershed Resources Division, Coastal Zone Management Program, Maryland Department of Natural Resources, Tidewater Administration, Annapolis, Maryland. 1994.
15. Maryland DNR. *Maryland Biological Stream Survey, Ecological Status of Nontidal Streams in Six Basins Sampled in 1995.* Chesapeake Bay and Watershed Programs, Monitoring and Nontidal Assessment. CBWP-MANTA-EA-97-2. May 1997.

16. Homer, M.L., M. Tarnowski, and L. Baylis. A Shellfish Inventory of Chincoteague Bay, Maryland. Final Report to Coastal and Watershed Resources Division, Coastal Zone Management Program, Maryland Department of Natural Resources, Tidewater Administration, Annapolis, Maryland. 1994.
17. Greenhawk, Kelly. Personal communication with Kelly Greenhawk, Sarbanes Cooperative Oxford Lab, DNR Fisheries Service. October 2000.
18. Maryland DNR. *Dissolved Oxygen in the Coastal Bays.* Fact sheet by the Tidewater Ecosystem Assessment Division. 2002. 8 pages
19. McGinty, M., C. Wazniak, et al. June 2003 DRAFT *The Benthic Macroalgae Community of the Maryland Coastal Bays Data Summary, 2001 Survey.* Maryland DNR Resource Assessment Service. 39 pages.
20. Dillow, J. W. Banks and M. Smigaj. *Groundwater Quality and Discharge to Chincoteague and Sinepuxent Bays Adjacent to Assateague Island National Seashore, Maryland.* US Geological Survey, Water Resources Investigations Report 02-4029. 2002. 42 pages.
21. Dillow, J. and E. Greene. *Groundwater Discharge and Nitrate Loadings to the Coastal Bays of Maryland.* US Geological Survey Water-Resources Investigations Report (WRIR) 99-4167. 8 pages.
22. Hairston-Strang, A., B. Harding, K. Powers. *Maryland Coastal Bays Forestry Strategy.* Maryland DNR Forest Service. April 2002. 43 pages.
23. DNR Fisheries Service. Fact sheet for Governor Ehrlich dated August 11, 2003.
24. Casey, JF. SB Doctor, AE Wesche. *Investigation of Maryland's Atlantic Ocean and Coastal Bay Finfish Stocks.* Maryland DNR Fisheries Service. Federal Aid Project No. F-50-R. 2001. 43 pages.
25. Casey, JF. *Current Status of Important FinFish Stocks in Maryland's Coastal Bays.* Maryland DNR Fisheries Service. Technical Report No. 30. 20 pages.
26. Neff, Kelly. Maryland Department of the Environment. Personal communication November 20, 2003.

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.

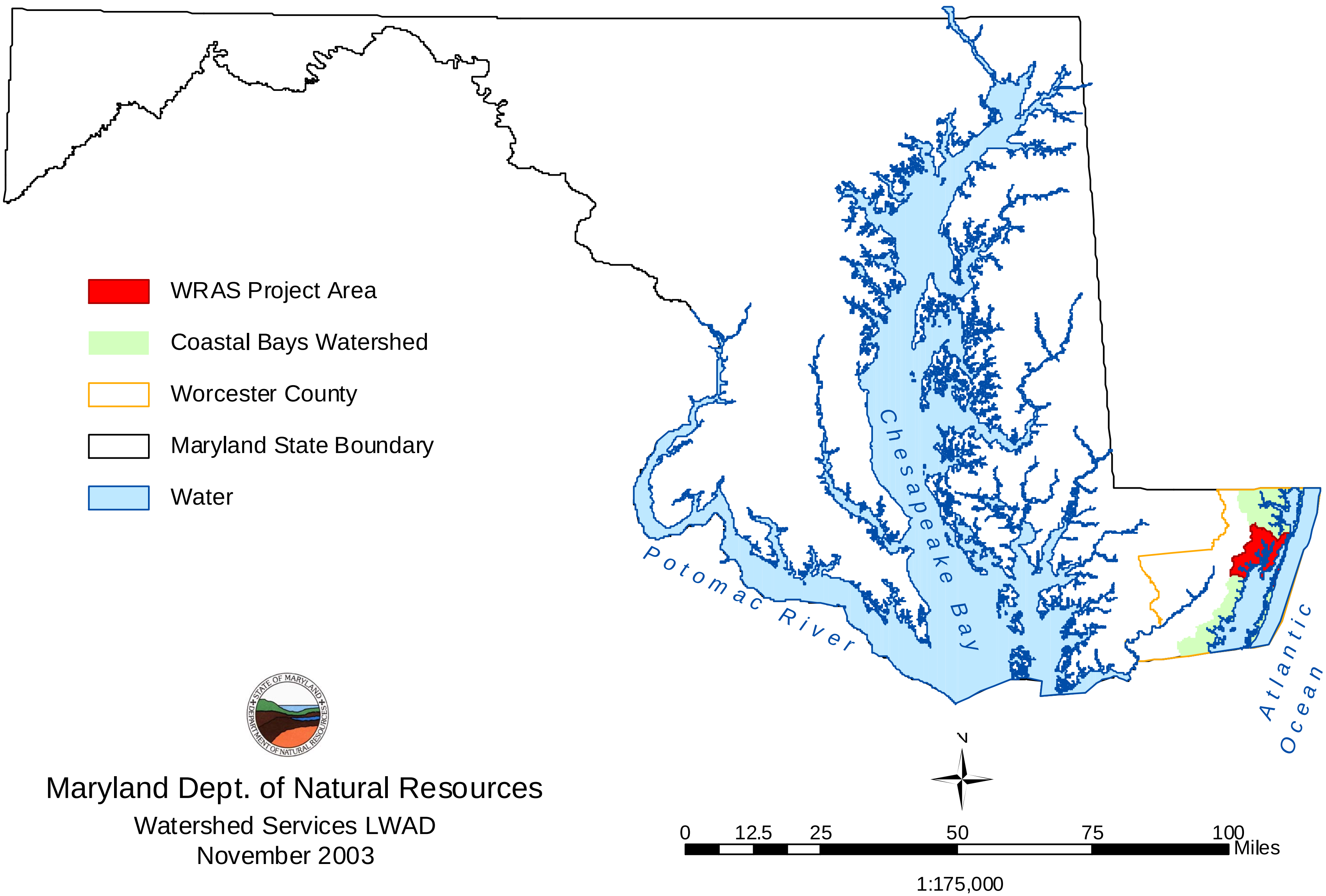
CRP	Conservation Reserve Program, a program of Farm Service Agency in cooperation with local Soil Conservation Districts. CRP encourages farmers to take highly erodible and other environmentally-sensitive farm land out of production for ten to fifteen years.
CWAP	Clean Water Action Plan, promulgated 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, in the Department of Interior.
USGS	United States Geological Survey

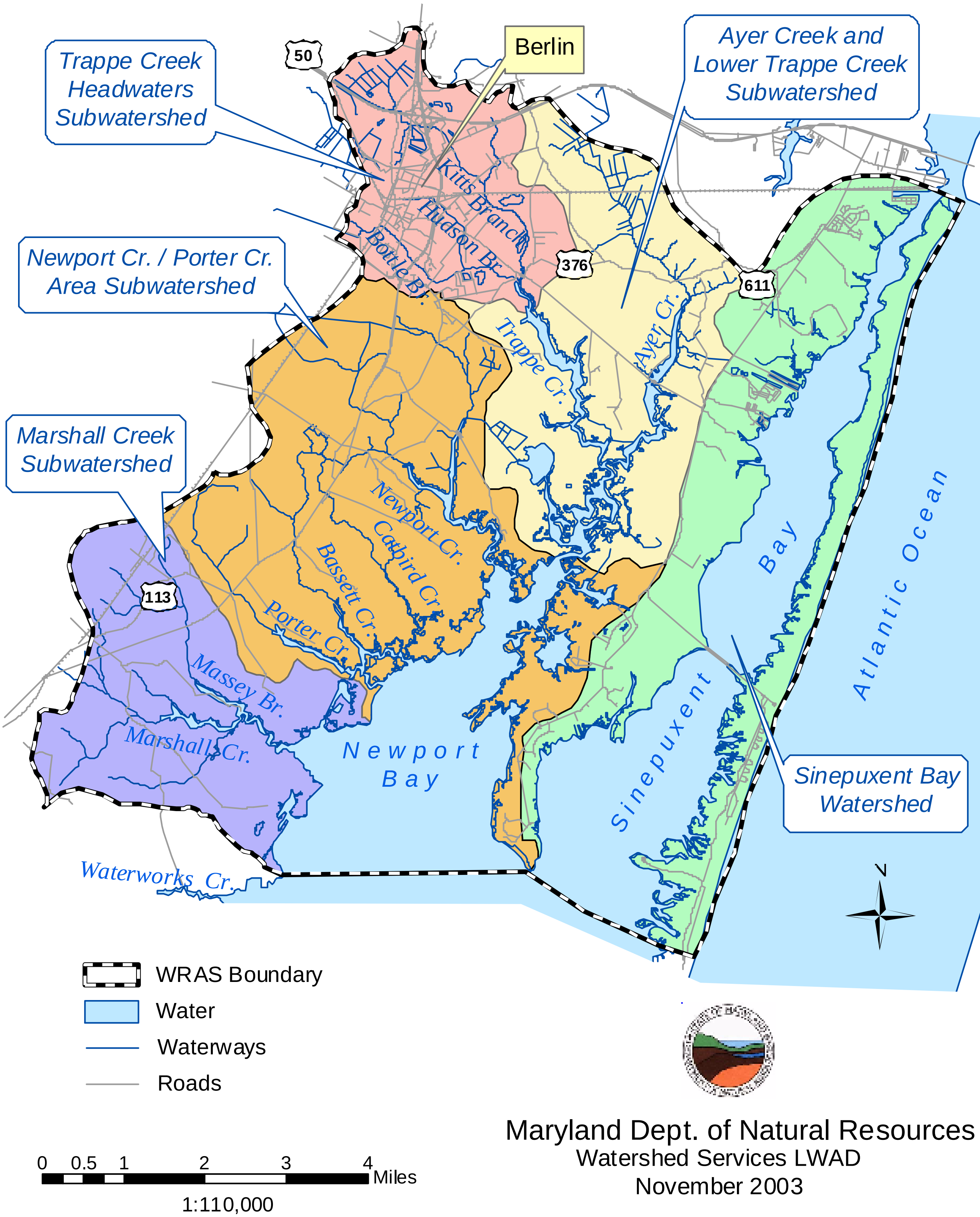
Water Quality Standard	Surface water quality standards consist of two parts: (a) designated uses of each water body; and (b) water quality criteria necessary to support the designated uses. Designated uses of for all surface waters in Maryland (like shell fish harvesting or public water supply) are defined 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
Newport Bay and Sinepuxent Bay WRAS Project Area



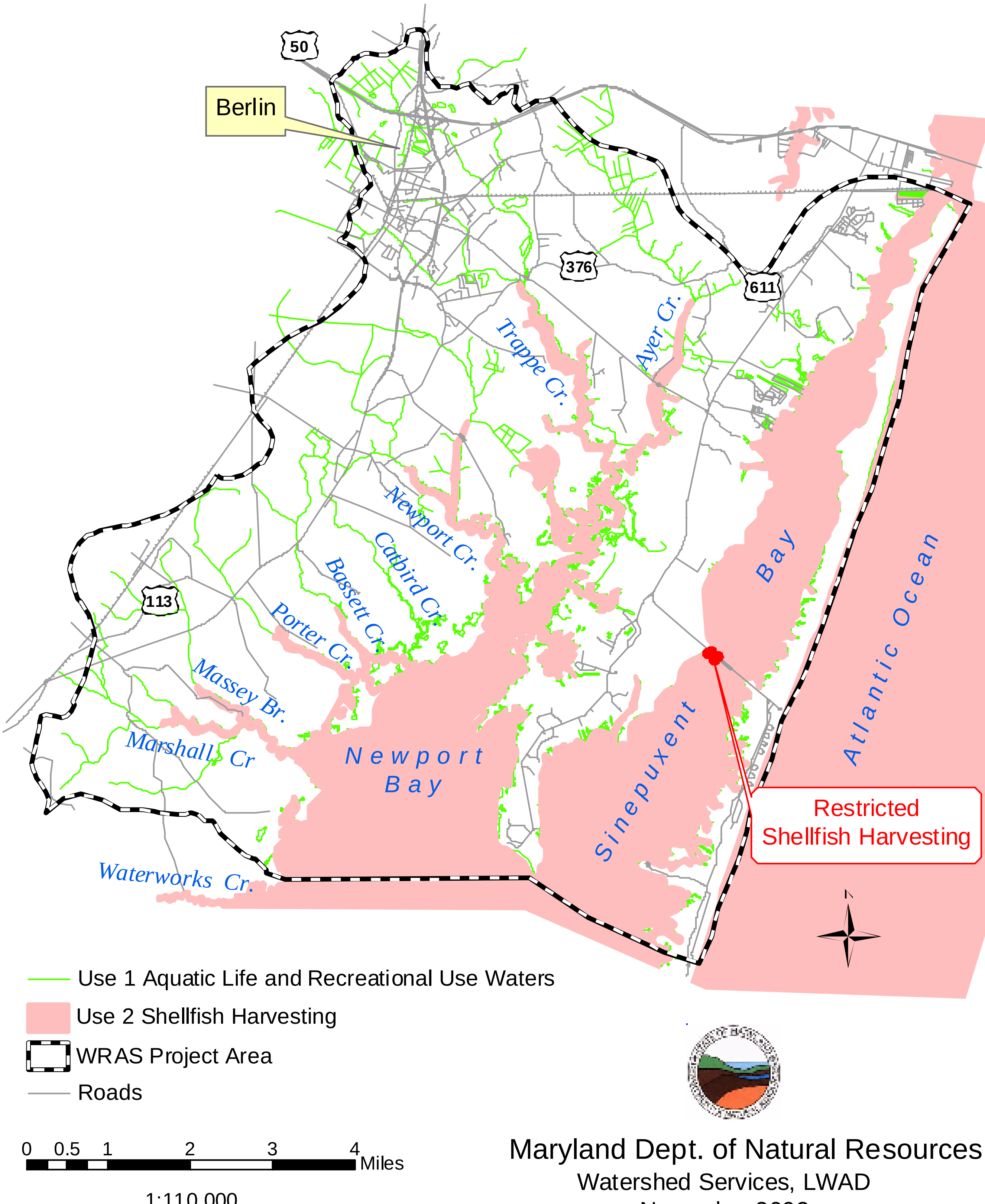
Maryland Dept. of Natural Resources
Watershed Services LWAD
November 2003

Map 2 WRAS Project Area
Newport Bay and Sinepuxent Bay Watersheds



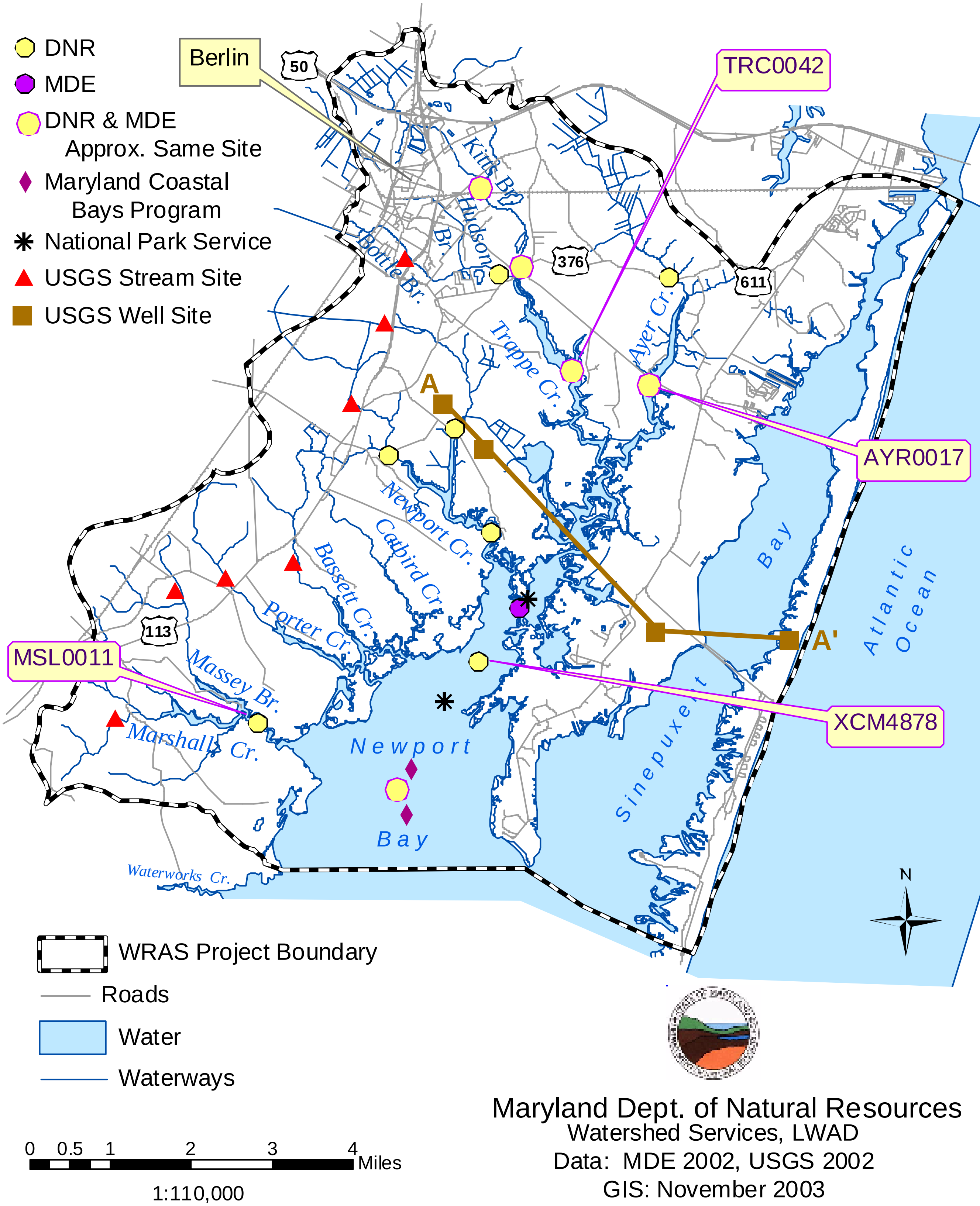
Maryland Dept. of Natural Resources
Watershed Services LWAD
November 2003

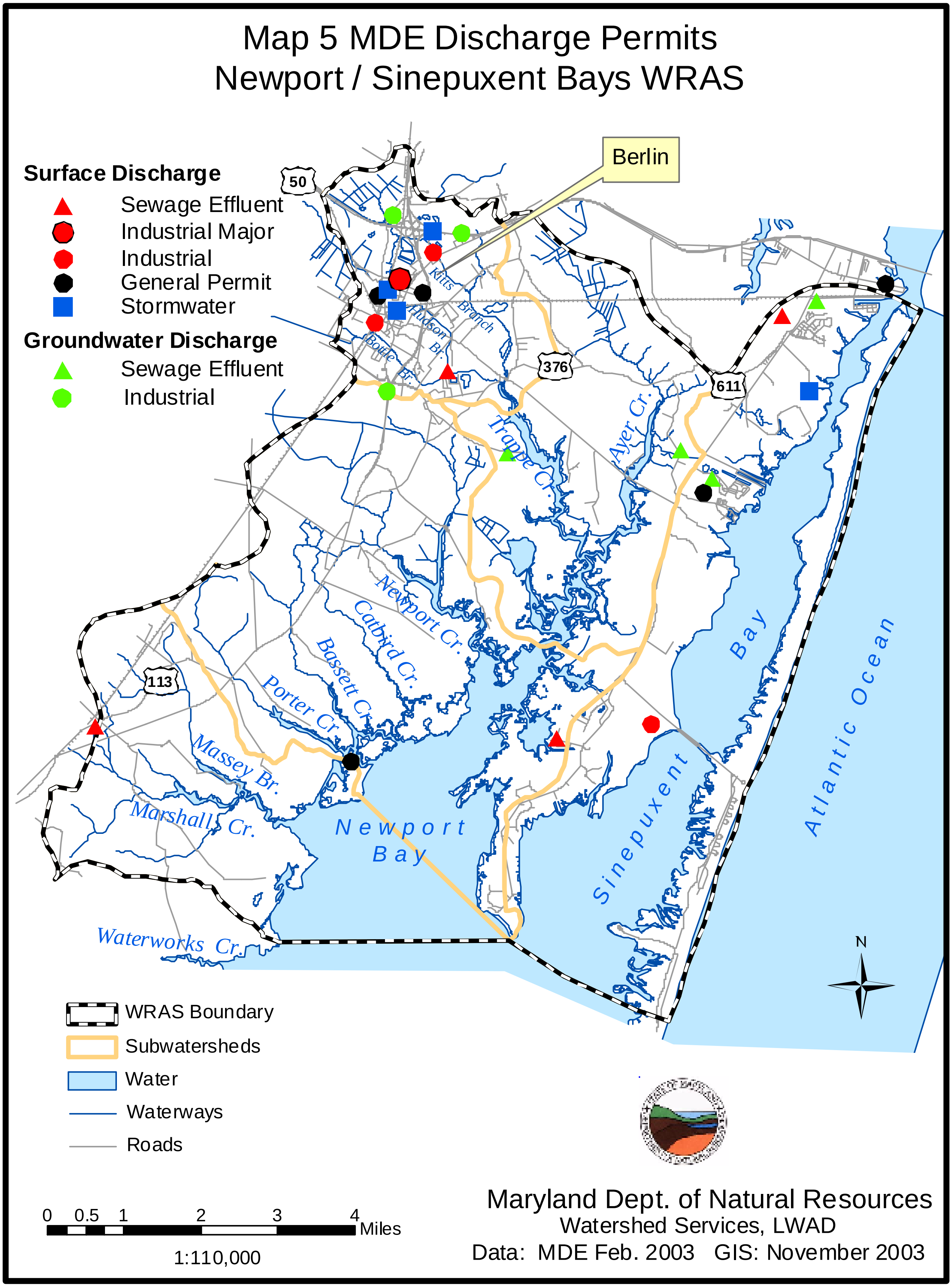
Map 3 Designated Use And Use Restrictions
Newport Bay and Sinepuxent Bay Watersheds



Maryland Dept. of Natural Resources
Watershed Services, LWAD
November 2003

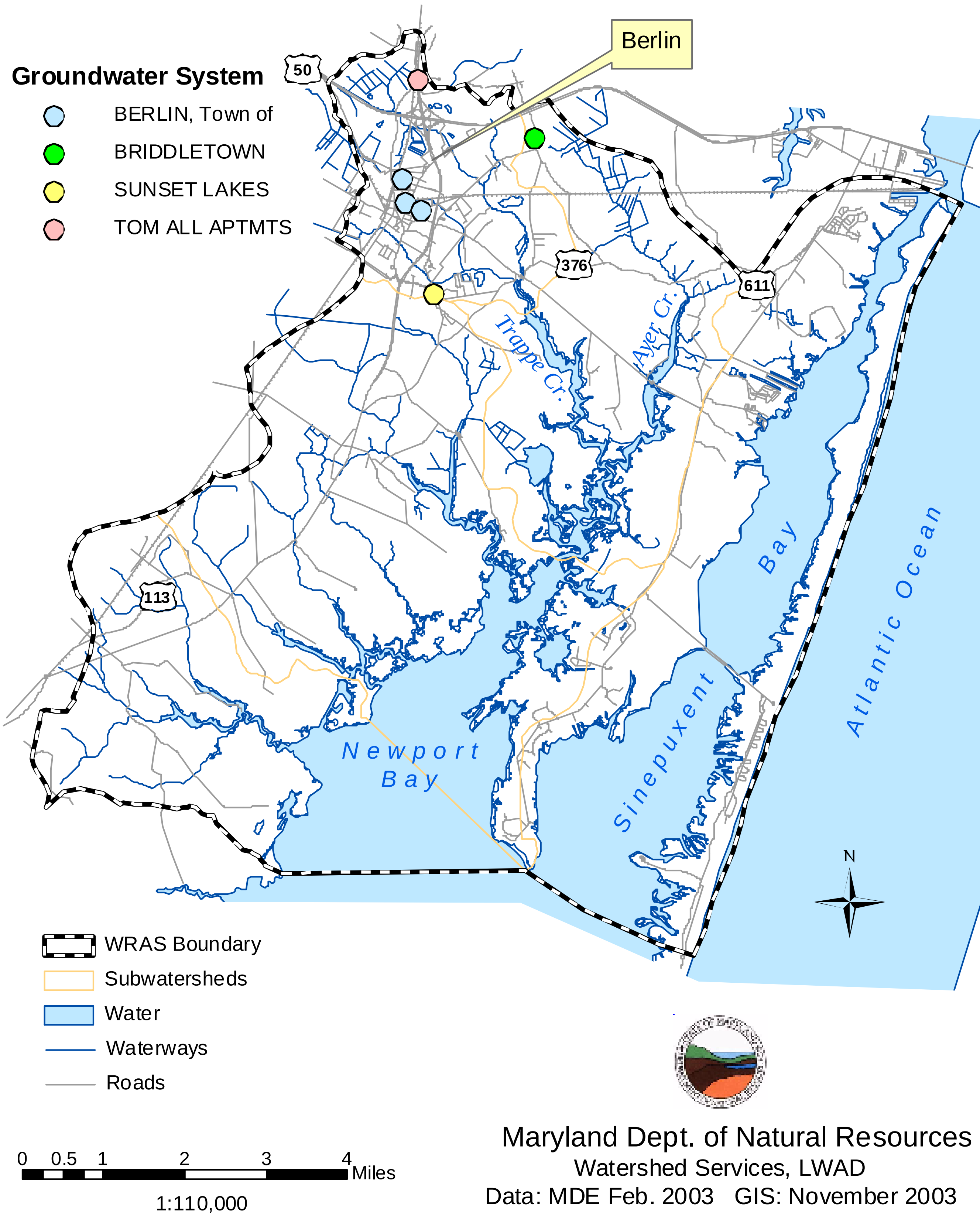
Map 4 Monitoring Water Quality
Newport Bay and Sinepuxent Bay Watersheds





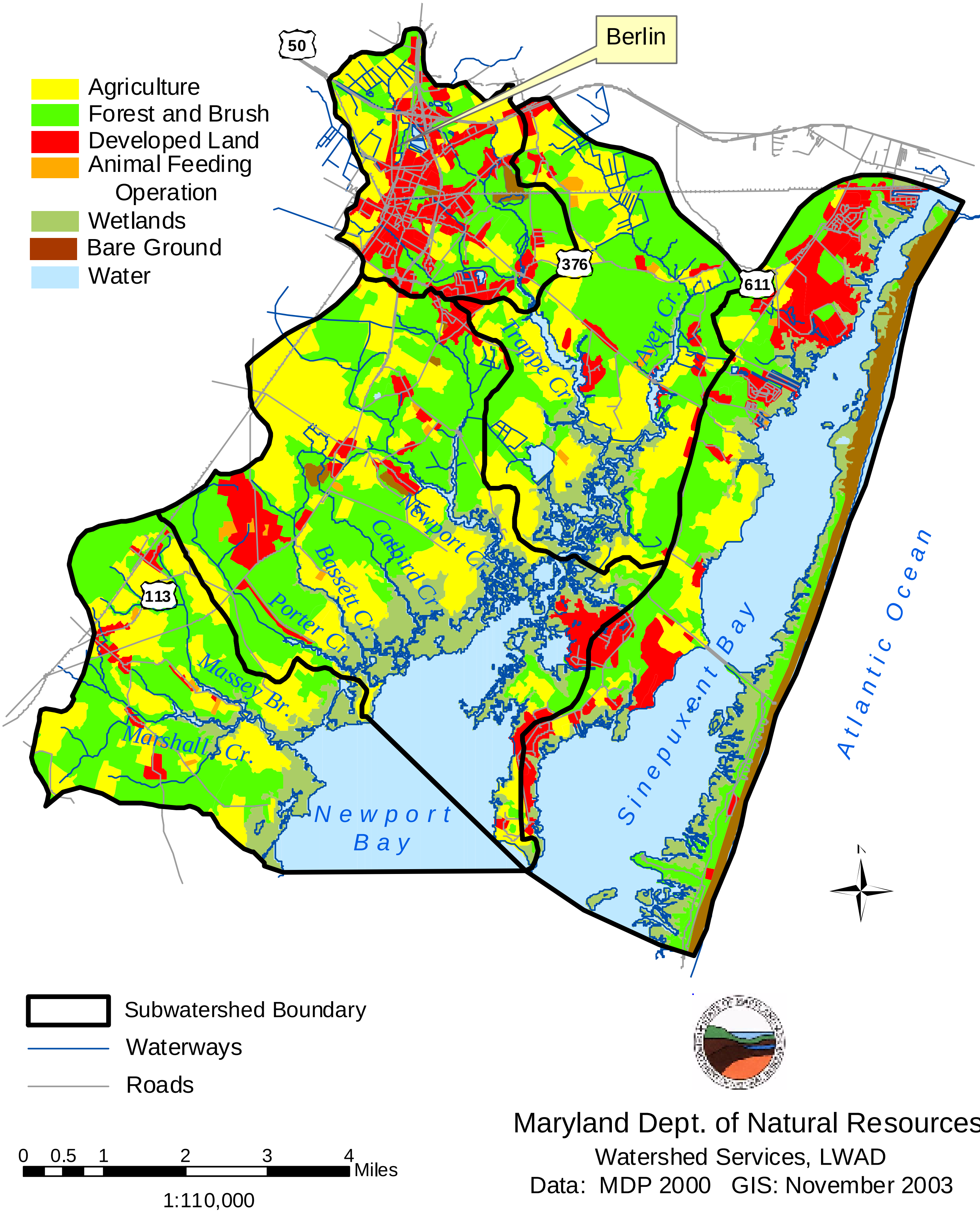
Map 5 MDE Discharge Permits
Newport / Sinepuxent Bays WRAS
Surface Discharge
Sewage Effluent
Industrial Major
Industrial
General Permit
Stormwater
Groundwater Discharge
Sewage Effluent
Industrial
Berlin
50
376
611
113
Kitts Branch
Hudson Br.
Bottle Br.
Trappe Cr.
Ayer Cr.
Newport Cr.
Catbird Cr.
Bassett Cr.
Porter Cr.
Massey Br.
Marshall Cr.
Waterworks Cr.
Newport Bay
Sinepuxent Bay
Atlantic Ocean
N
WRAS Boundary
Subwatersheds
Water
Waterways
Roads
0 0.5 1 2 3 4 Miles
1:110,000
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDE Feb. 2003 GIS: November 2003

Map 6 Community Water Systems
Newport Bay and Sinepuxent Bay Watersheds



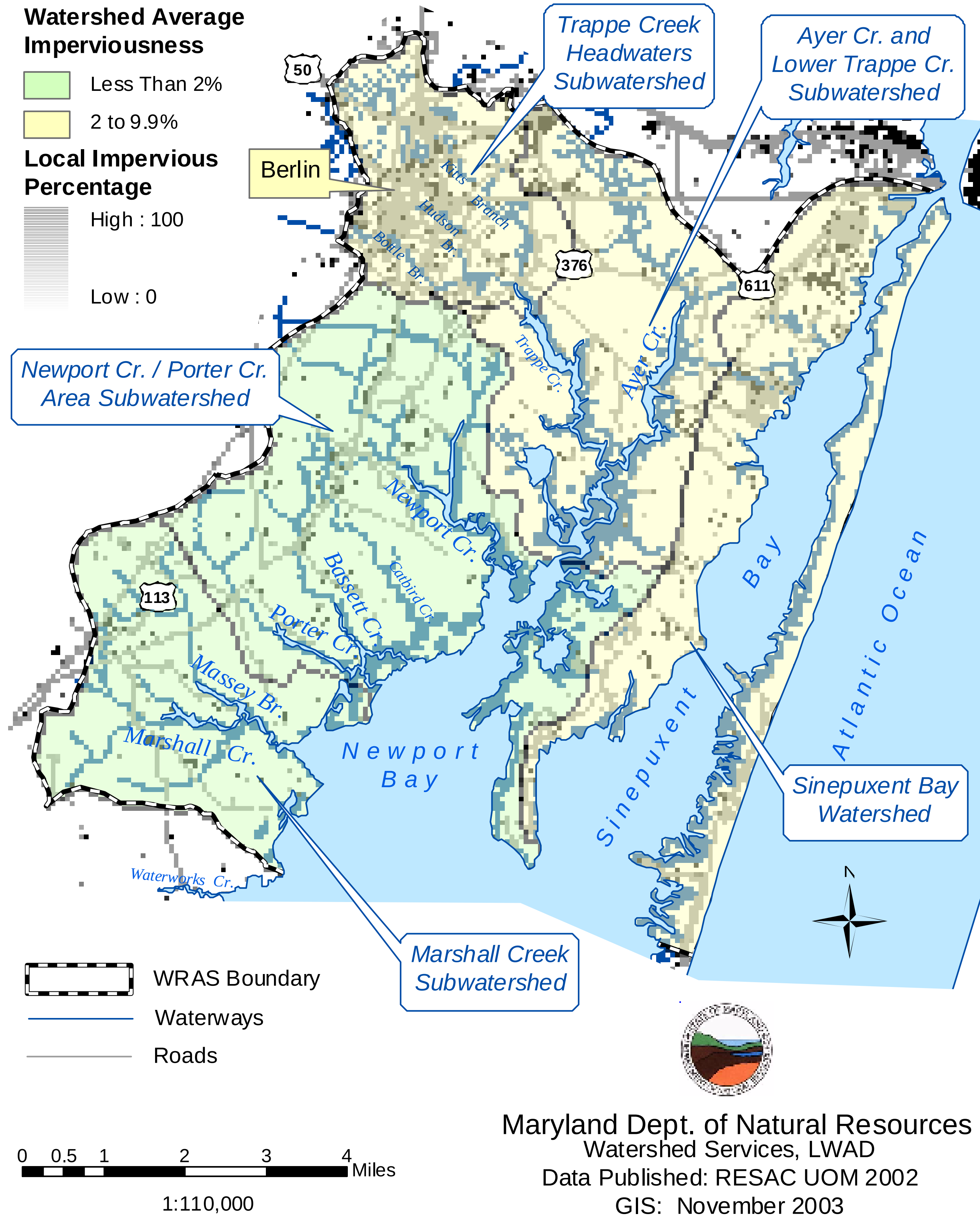
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDE Feb. 2003 GIS: November 2003

Map 7 Land Use / Land Cover
Newport Bay and Sinepuxent Bay Watersheds



Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP 2000 GIS: November 2003

Map 8 Impervious Surface
Newport Bay and Sinepuxent Bay Watersheds

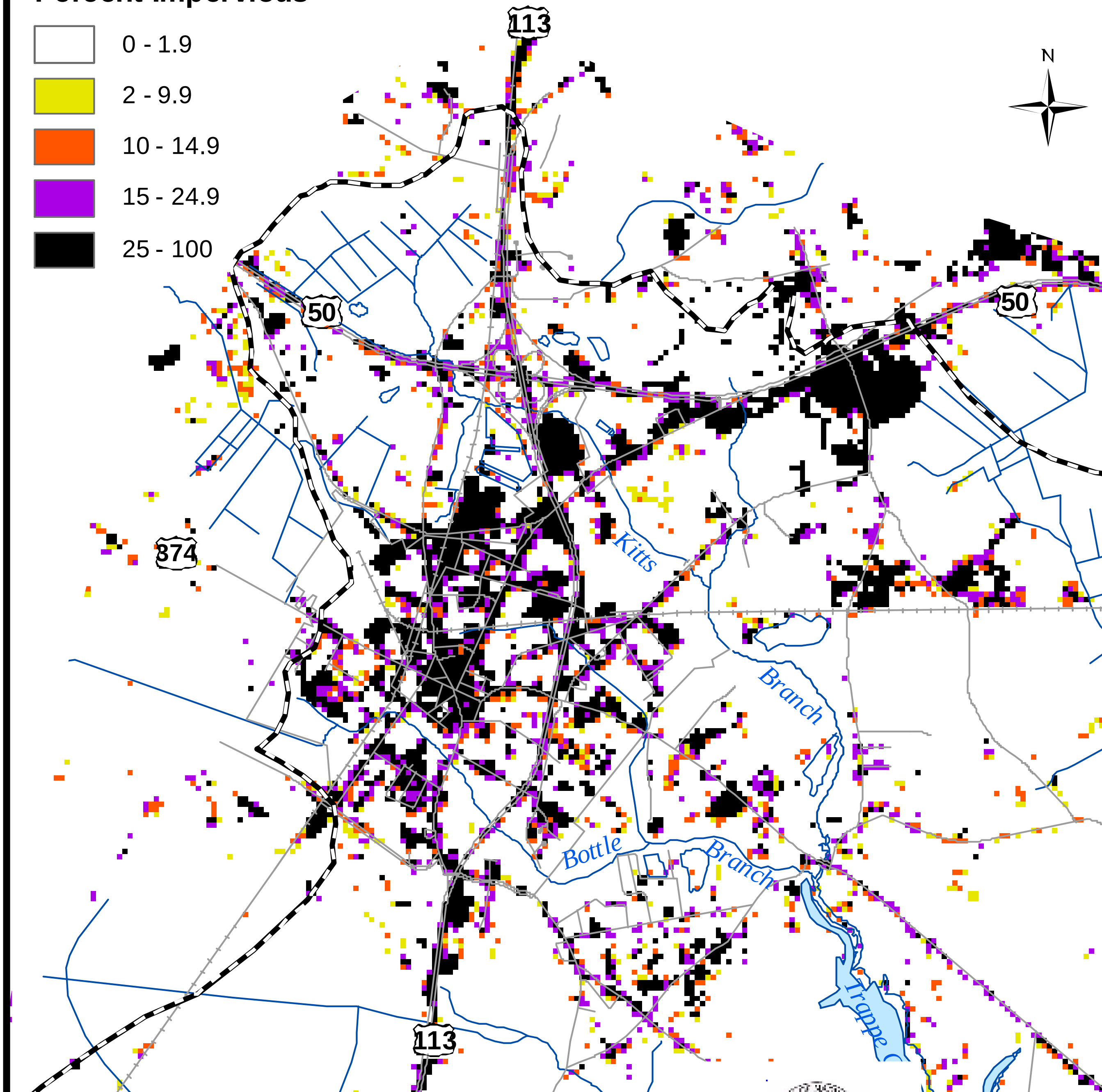


Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data Published: RESAC UOM 2002
GIS: November 2003

Map 9 Impervious Surface
Town of Berlin Vicinity

Percent Impervious

- 0 - 1.9
- 2 - 9.9
- 10 - 14.9
- 15 - 24.9
- 25 - 100

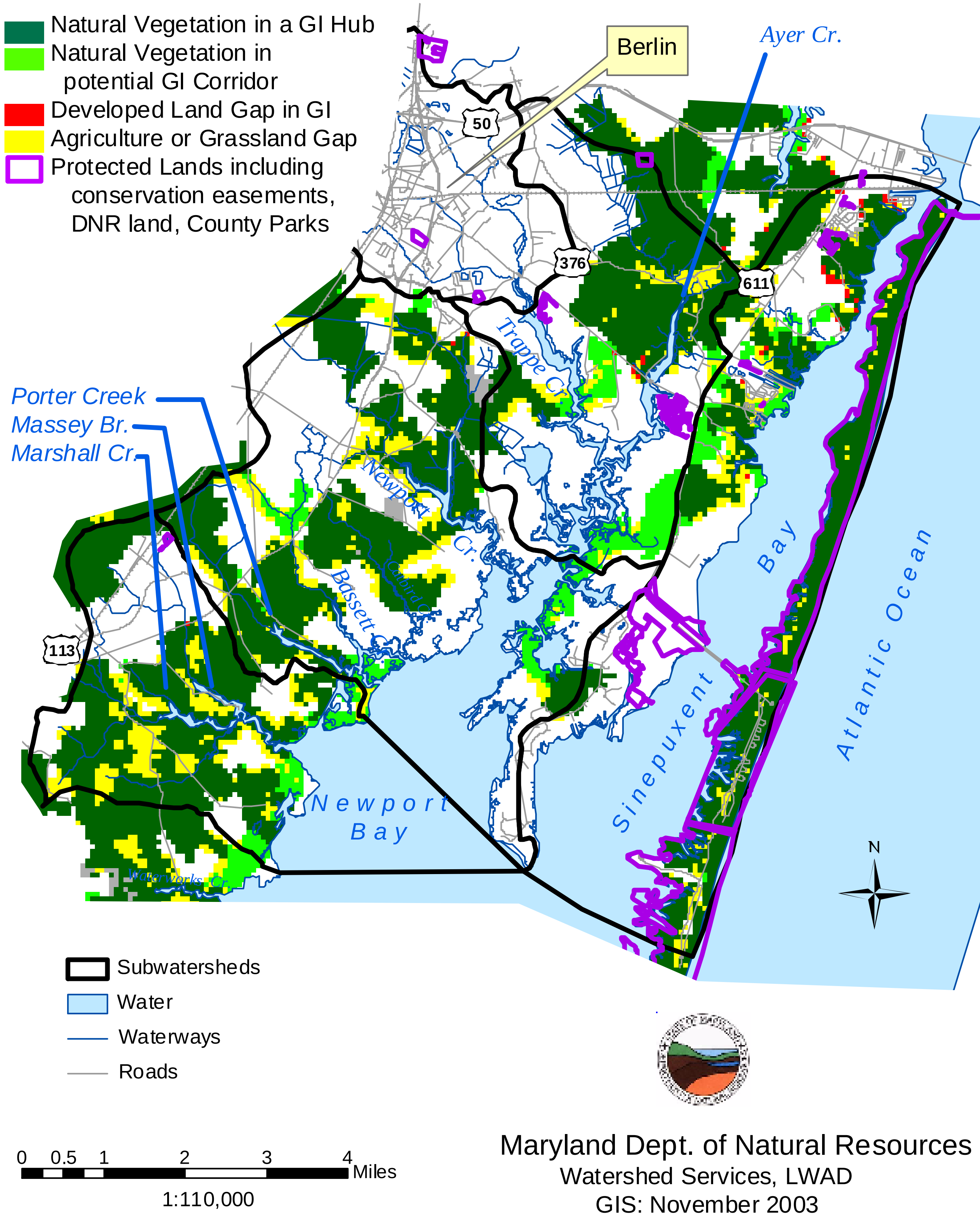


WRAS Boundary
Waterways
Roads

0 0.25 0.5 1 1.5 2 Miles
1:40,000

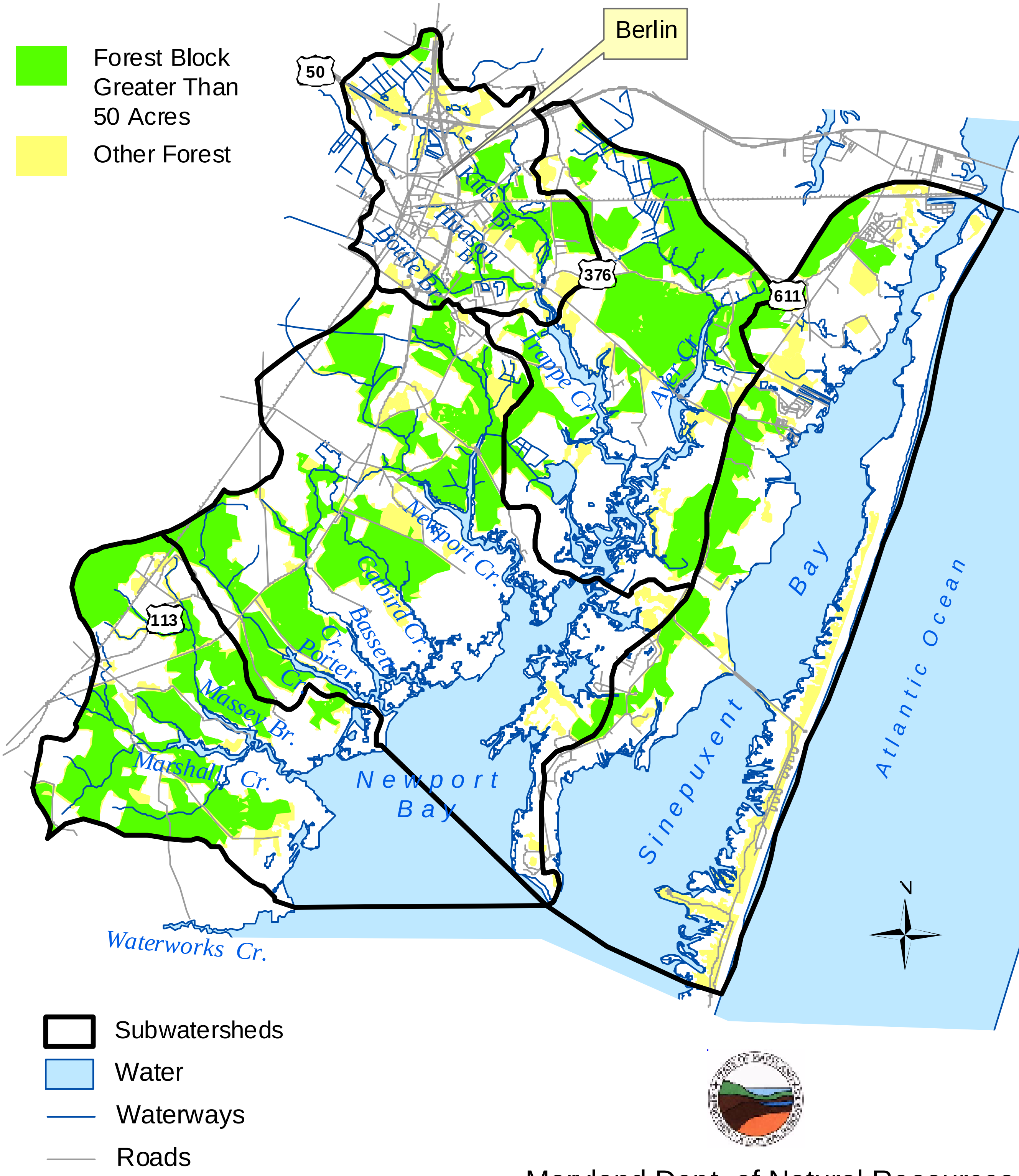
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data Published: RESAC UOM 2002
GIS: November 2003

Map 10 Green Infrastructure
Newport Bay and Sinepuxent Bay Watersheds



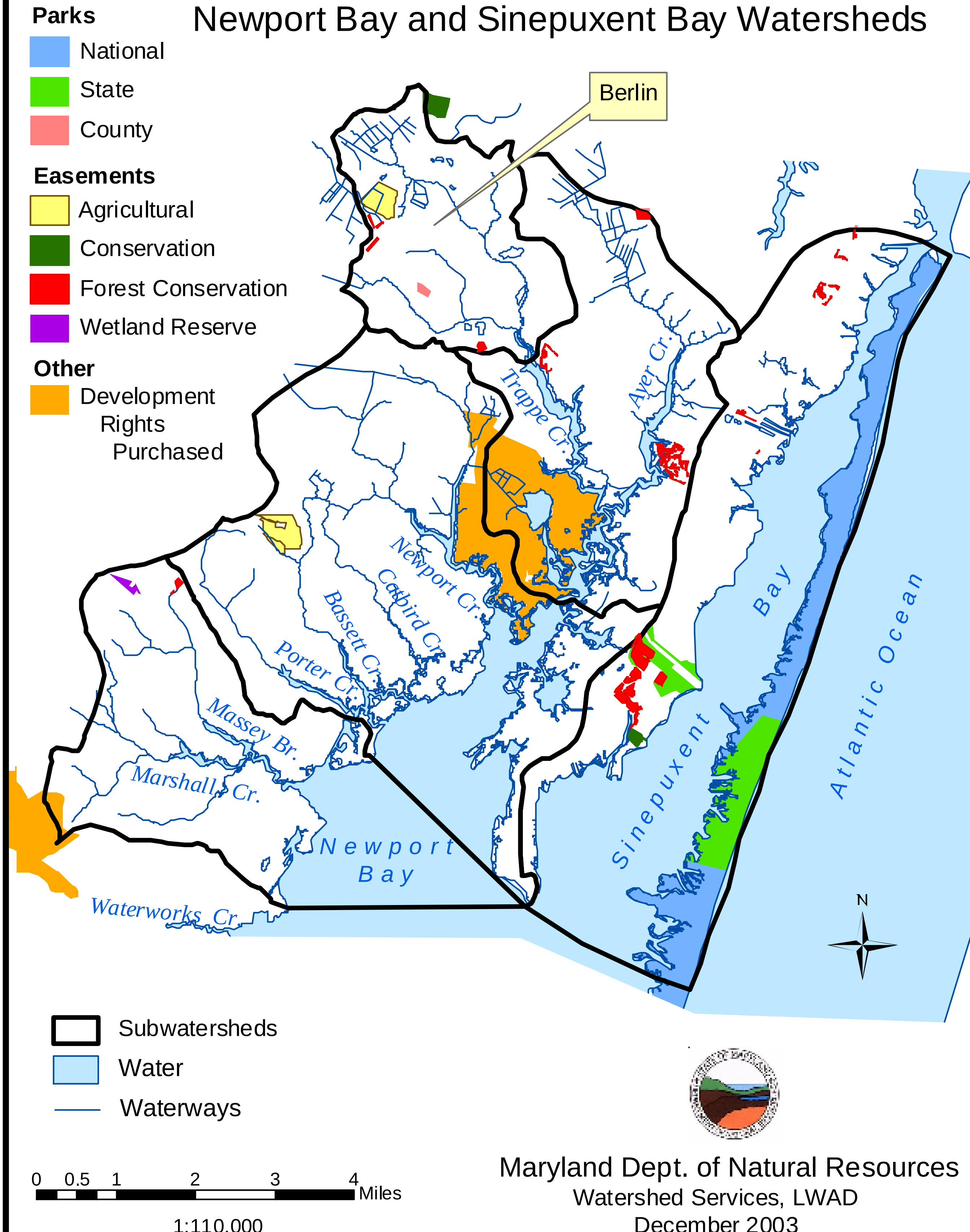
Maryland Dept. of Natural Resources
Watershed Services, LWAD
GIS: November 2003

Map 11 Forest Interior
Newport Bay and Sinepuxent Bay Watersheds



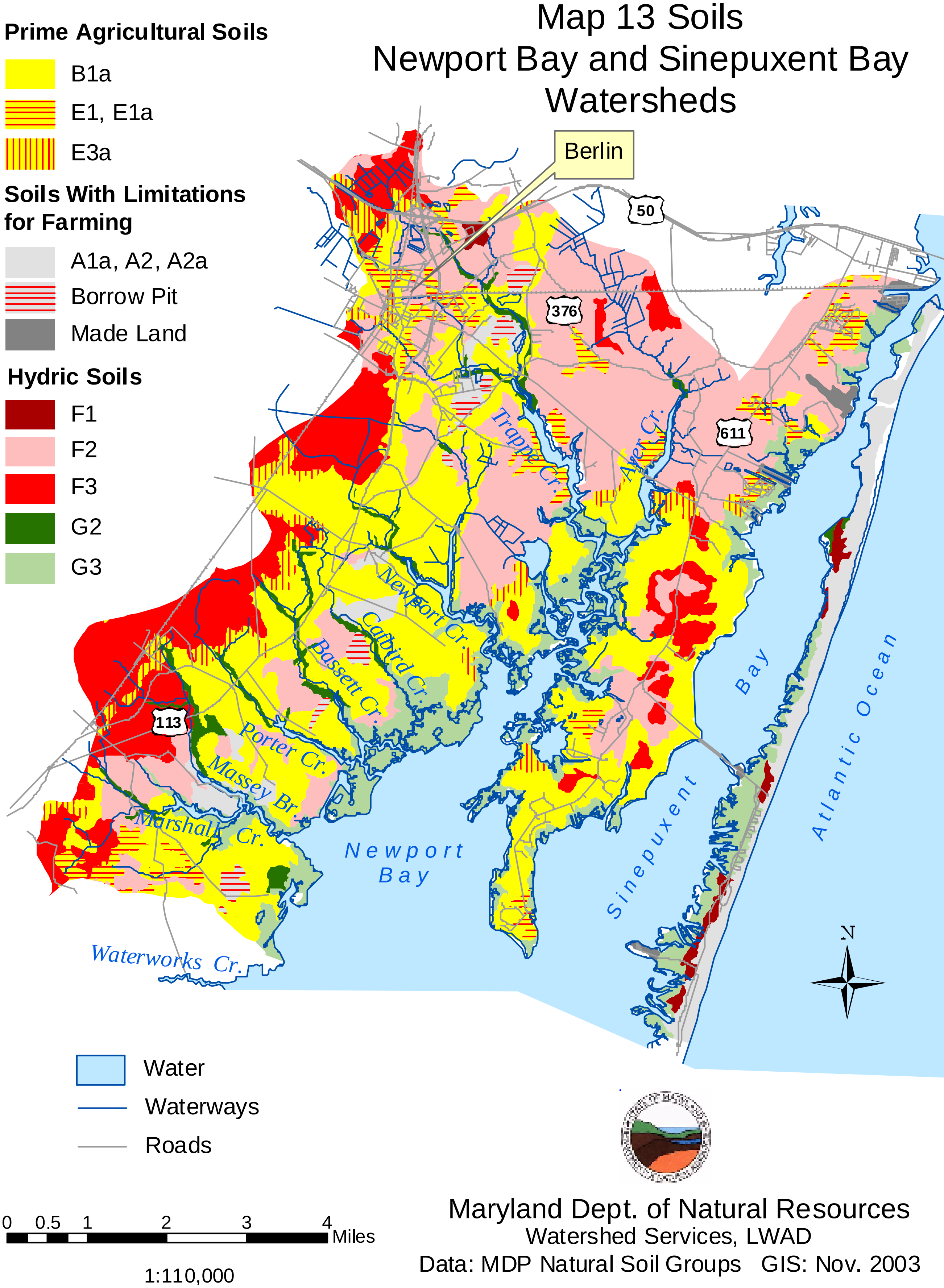
Maryland Dept. of Natural Resources
Watershed Services LWAD
Data: MDP 2000 GIS: November 2003

Map 12 Protected Land
Newport Bay and Sinepuxent Bay Watersheds

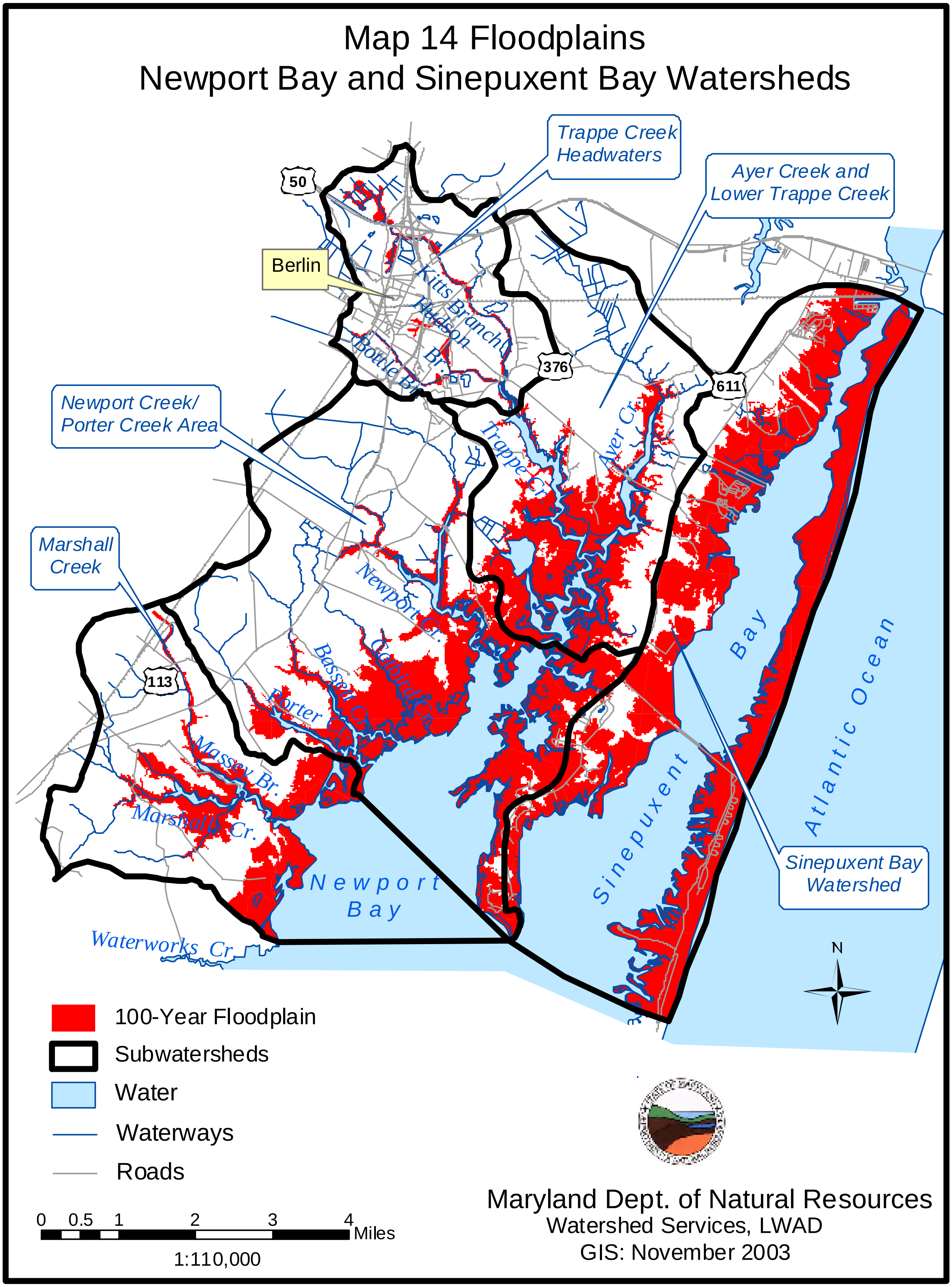


Maryland Dept. of Natural Resources
Watershed Services, LWAD
December 2003

Map 13 Soils
Newport Bay and Sinepuxent Bay Watersheds

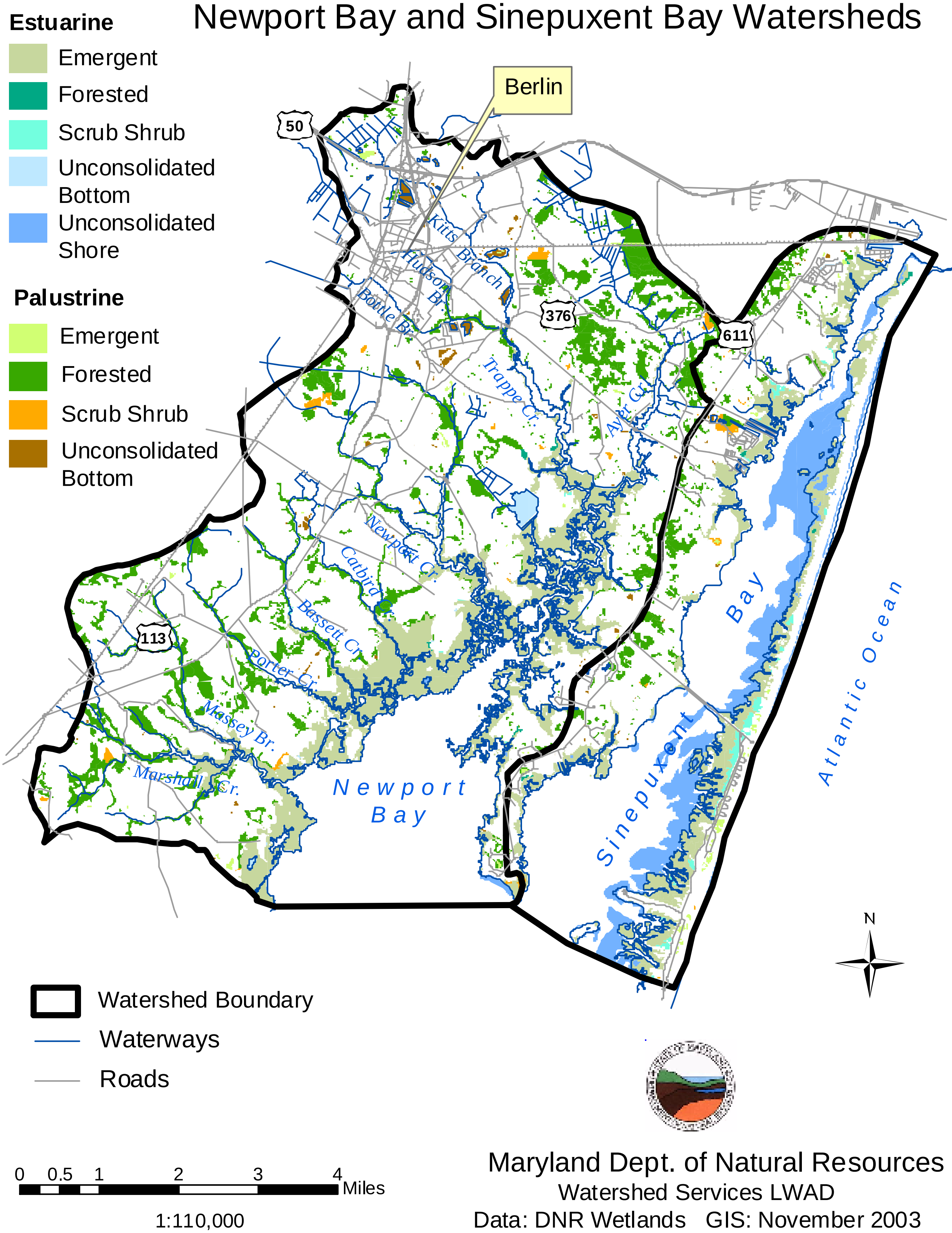


Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MDP Natural Soil Groups GIS: Nov. 2003



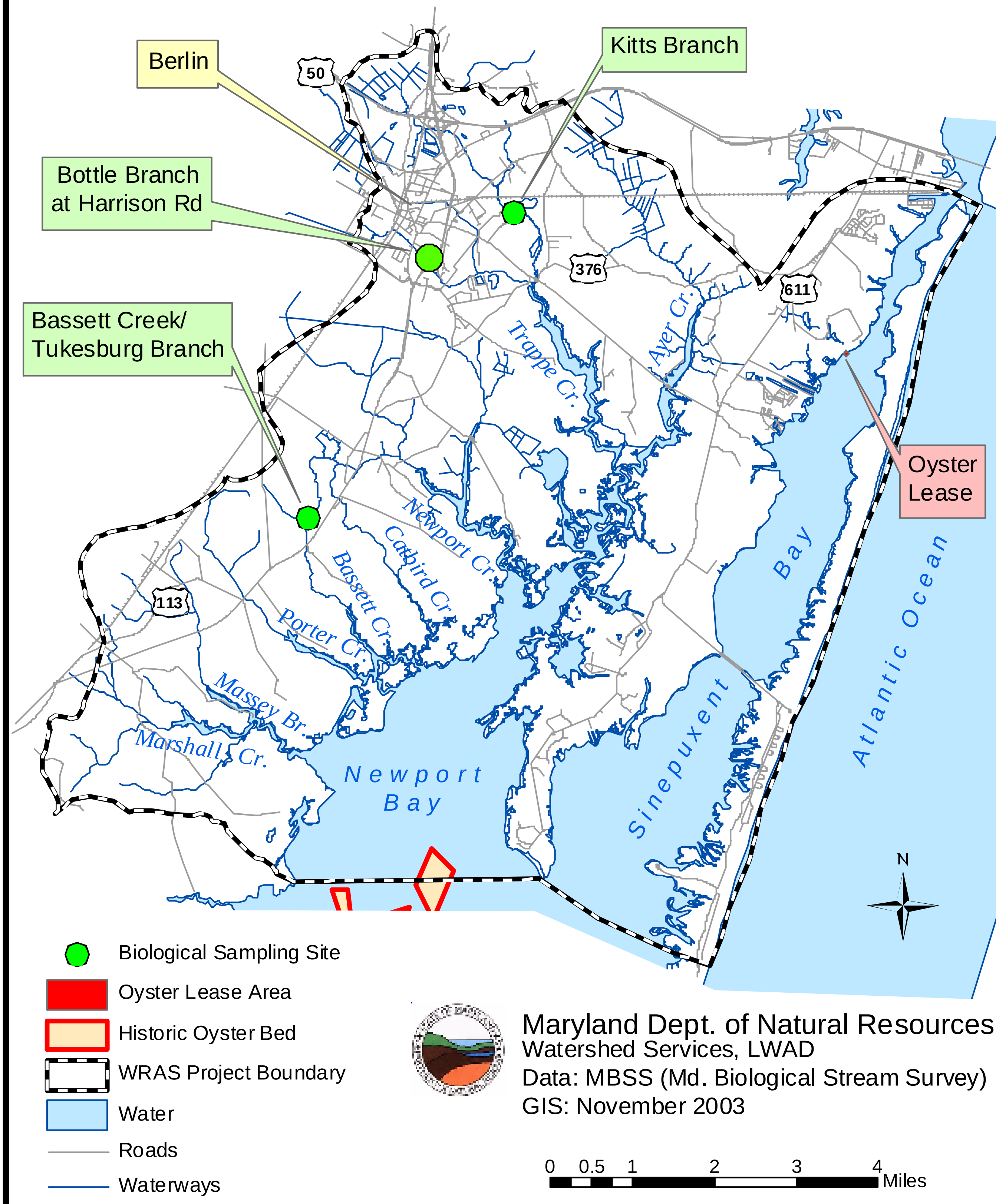
Map 14 Floodplains
Newport Bay and Sinepuxent Bay Watersheds
Trappe Creek Headwaters
Ayer Creek and Lower Trappe Creek
50
Berlin
Kitts Branch
Hudson Br.
Bottle Br.
376
611
Newport Creek/ Porter Creek Area
Trappe Cr.
Ayer Cr.
Marshall Creek
Newport Cr.
Bassett Cr.
Cabin Cr.
Porter Cr.
113
Massey Br.
Marshall Cr.
Newport Bay
Waterworks Cr.
Sinepuxent Bay
Atlantic Ocean
Sinepuxent Bay Watershed
N
100-Year Floodplain
Subwatersheds
Water
Waterways
Roads
0 0.5 1 2 3 4 Miles
1:110,000
Maryland Dept. of Natural Resources
Watershed Services, LWAD
GIS: November 2003

Map 15 Wetlands
Newport Bay and Sinepuxent Bay Watersheds



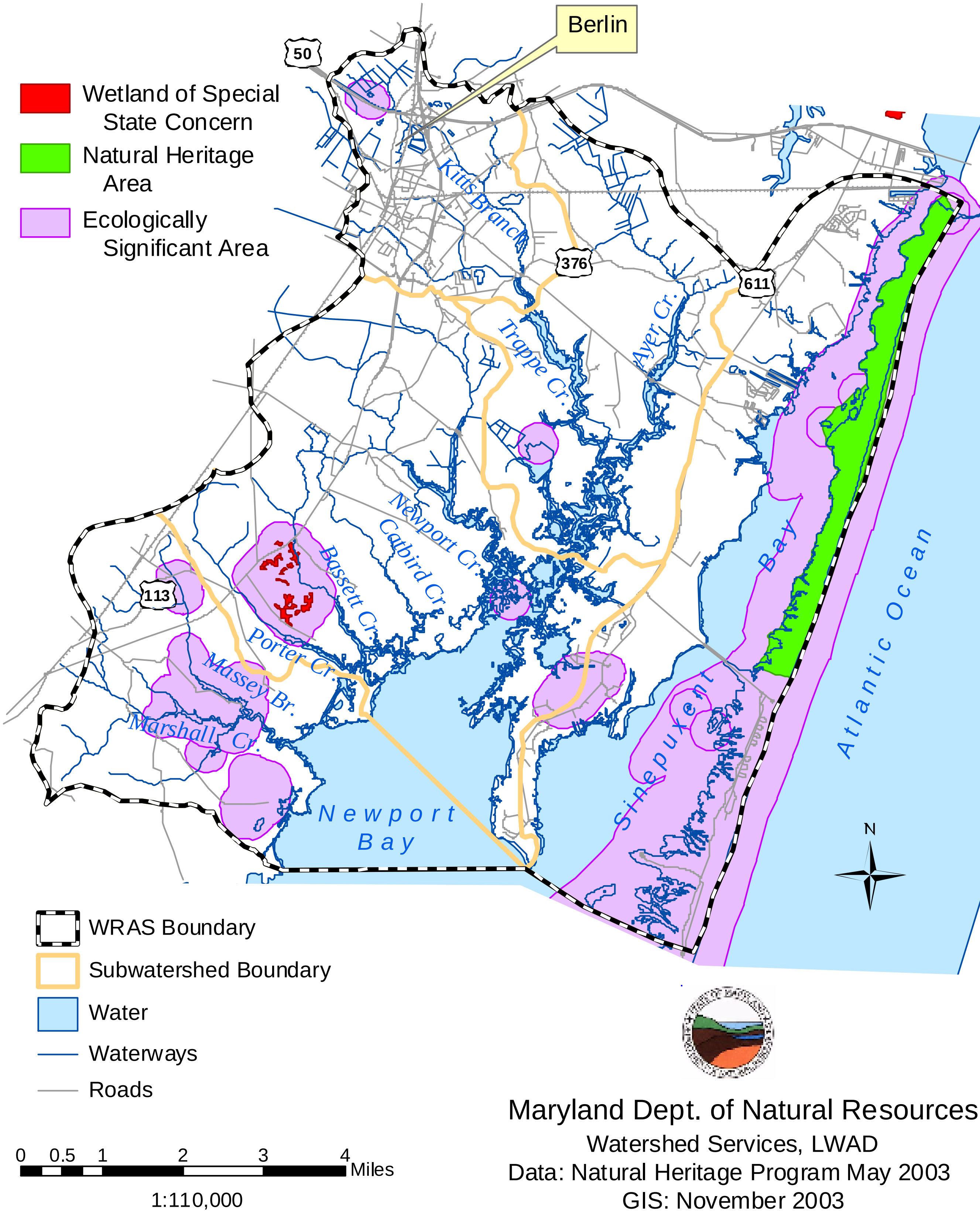
Maryland Dept. of Natural Resources
Watershed Services LWAD
Data: DNR Wetlands GIS: November 2003

Map 16 Biological Sampling Sites and Oyster Status
Newport Bay & Sinepuxent Bay Watersheds



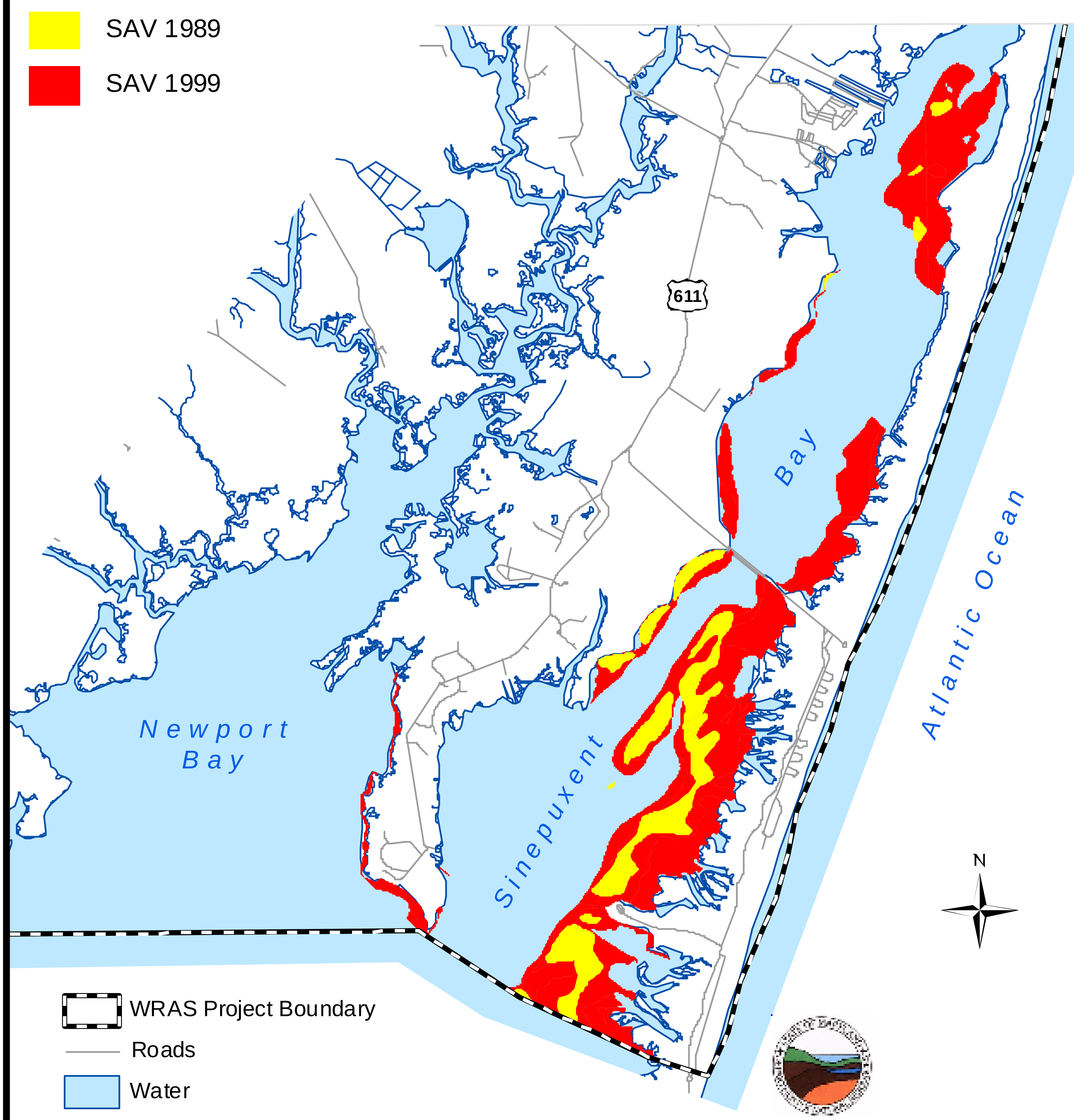
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: MBSS (Md. Biological Stream Survey)
GIS: November 2003

Map 17 Sensitive Species
Newport Bay and Sinepuxent Bay Watersheds



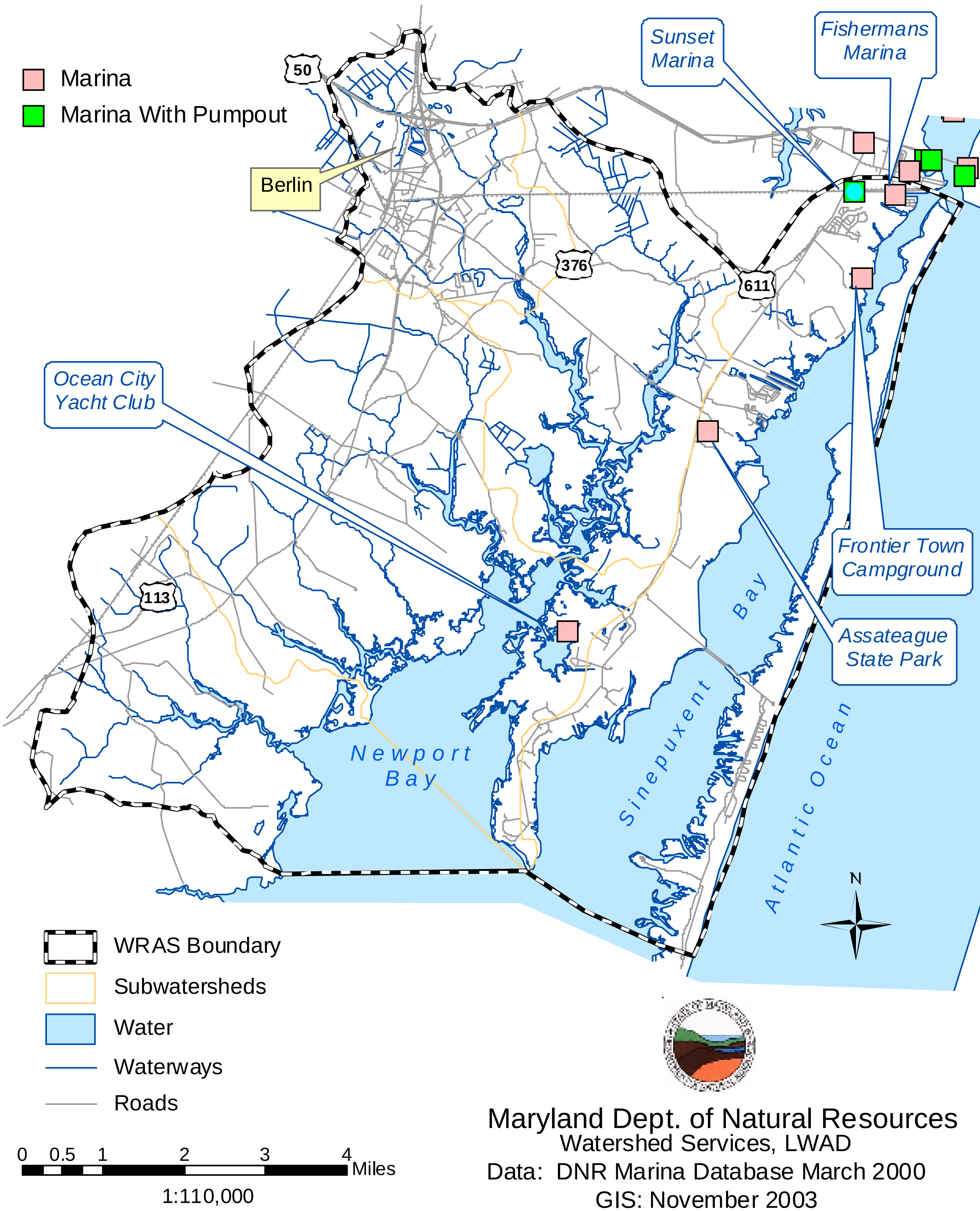
Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: Natural Heritage Program May 2003
GIS: November 2003

Map 18 Submerged Aquatic Vegetation
Newport Bay and Sinepuxent Bay Watersheds



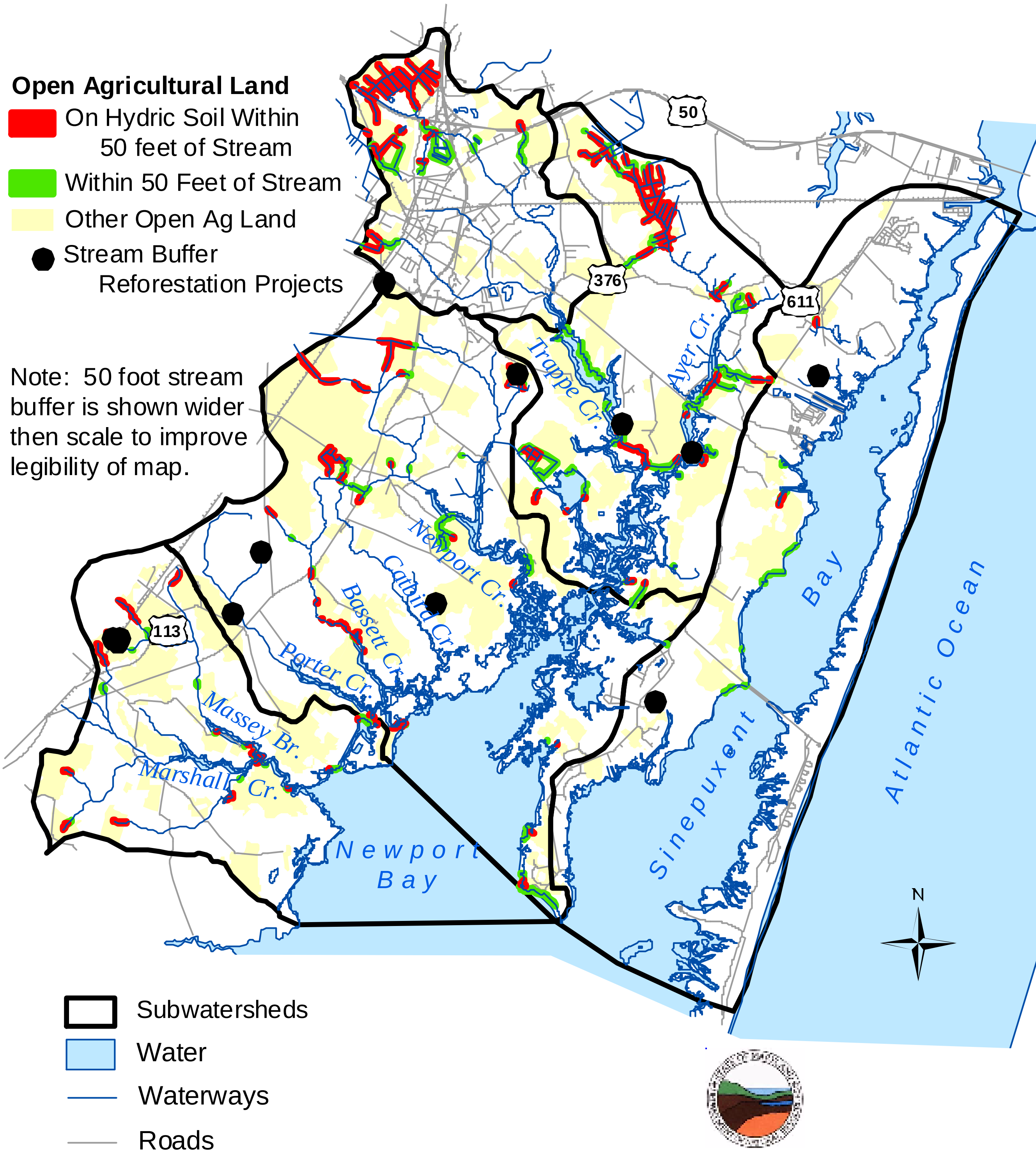
Maryland Dept. of Natural Resources
Watershed Services, LWAD
November 2003

Map 19 Marinas
Newport Bay and Sinepuxent Bay Watersheds



Maryland Dept. of Natural Resources
Watershed Services, LWAD
Data: DNR Marina Database March 2000
GIS: November 2003

Map 20 Stream Buffer Scenario
Newport Bay and Sinepuxent Bay Watersheds

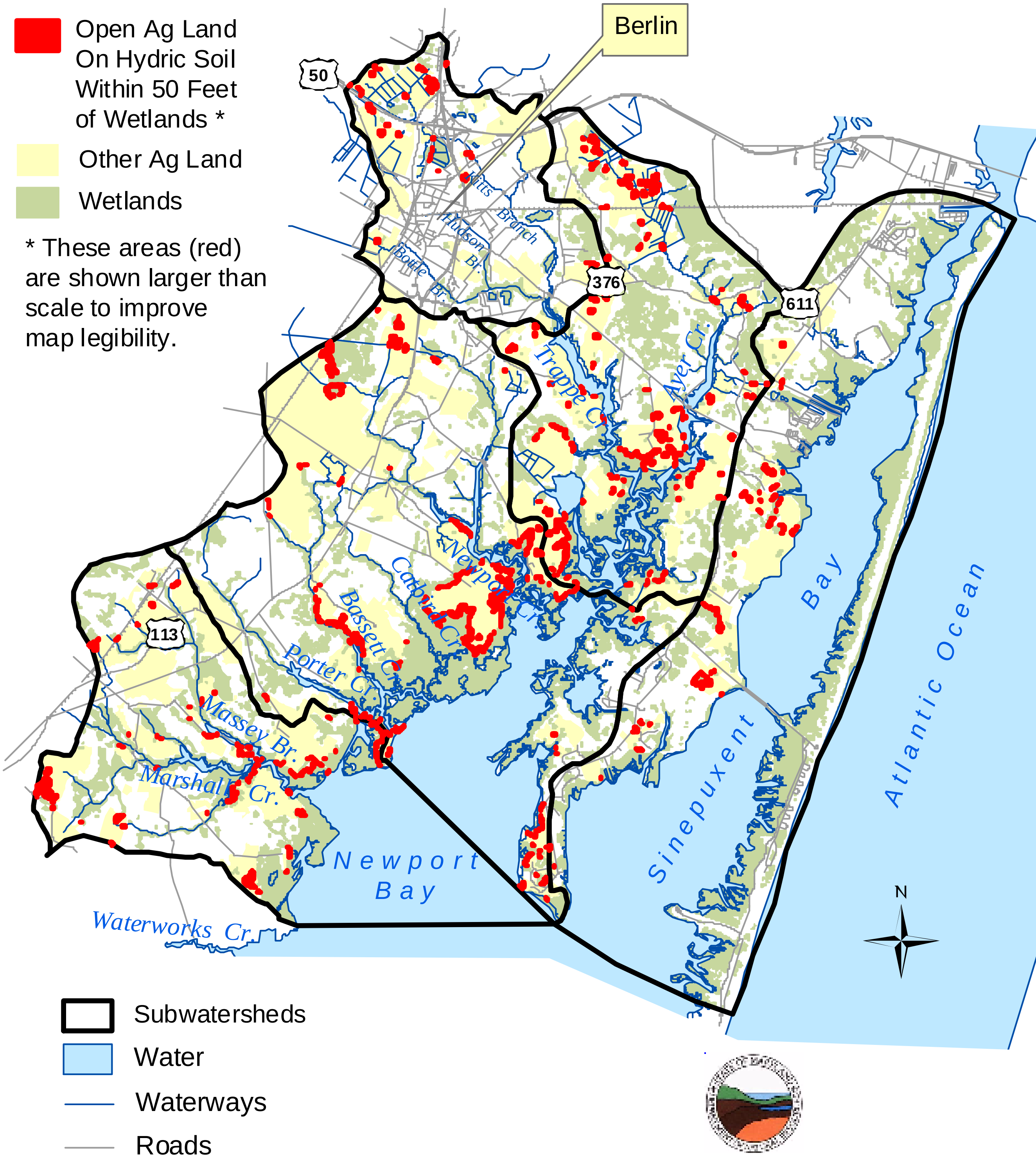


0 0.5 1 2 3 4 Miles

1:110,000

Maryland Dept. of Natural Resources
Watershed Services, LWAD
GIS: November 2003. Data: MDP 2000, SSURGO Soils, Forest Service Buffer Database 2002

Map 21 Wetlands Restoration Scenario
Newport Bay and Sinepuxent Bay Watersheds



0 0.5 1 2 3 4 Miles

1:110,000

Maryland Dept. of Natural Resources
Watershed Services, LWAD
GIS: November 2003 Data: MDP 2000 Ag Land, SSURGO Soils, DNR Wetlands